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CHEMICAL PROBLEMS.

WITH

BRIEF STATEMENTS OF THE PRINCIPLES INVOLVED.

BY

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PREFACE.

THE value of problems as means for securing accuracy in a knowledge of Chemistry and as tests for attainments is recognized by the best educators in this country and Europe. Notwithstanding this there are very few volumes in the English language devoted solely to problems, and these are intended mainly to accompany certain text-books.

This work was written because the author keenly felt the need of a convenient volume of problems, while giving instruction to his classes. The inconveniences attending the dictation of problems and the liability to mistake on the part of students can be appreciated only by those who have attempted orally to meet the needs of their classes.

The plan adopted in this work is very simple. After defining the terms used as far as is thought necessary, and briefly stating the principle to be illustrated, a typical problem is solved, and from

the solution a formula of general application is deduced, which is followed by problems to be worked by the student. As the problems are given solely for the purpose of illustrating and fixing in the mind of the student some of the fundamental principles of Chemistry, the answers are appended so that he may not be perplexed by a feeling of uncertainty as to the correctness of his work. Problems after the model of those given can be multiplied very readily by the teacher, to meet the requirements of his classes.

APRIL, 1883.

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I.

Weights and Measures.

The necessary data for solving the problems in this section may be found in Tables I, II, and III in the Appendix.

1. Required the number of (*a*) centimetres, (*b*) decimetres, (*c*) metres in 1098765421 millimetres.

Ans. 109876542·1 centimetres.
10987654·21 decimetres.
1098765·421 metres.

2. How many square centimetres are there in 15·5 square metres?

Ans. 155,000.

3. How many square decimetres are contained in 108642 square centimetres?

Ans. 1086·42.

4. Required the number of square millimetres, square centimetres, square decimetres contained in the top of a table measuring 1 metre by 70 centimetres.

Ans. 70,000 square millimetres.
7,000 square centimetres.
70 square decimetres.

5. Calculate the number of square centimetres contained on the surface of a paper filter possessing a radius of 5 centimetres? *Ans.* 78·54.

6. There are how many cubic centimetres in a slab of marble 1·5 metres long, 7 decimetres wide, and 9 centimetres thick? How many litres of water will such a slab displace?

Ans. 94500 c. c.
94·5 litres.

7. A stick of timber 4 metres long and 3 decimetres wide has a solid contents of 240 cubic decimetres; what is its thickness? *Ans.* 2 decimetres.

8. What is the capacity in litres of a rectangular tank 2 metres long, 9 decimetres wide, and 8 decimetres deep?

Ans. 1440 litres.

9. What is the capacity of a spherical glass bulb which has a radius of 3 centimetres? *Ans.* 113·097 c. c.

10. How many grams are there in 1·725 kilograms? *Ans.* 1725.

11. How many centigrams are contained in 2·567 kilograms. *Ans.* 256700.

12. How many milligrams are contained in 5 cubic centimetres of water at 4° C ?

Ans. 5000.

13. What is the length of a centigram of wire 255 m. m. of which weighs 0·172 gram ? *Ans.* 14·826 m. m.

14. A piece of platinum foil measuring 10·5 centimetres by 1·5 centimetres weighs 0·723 gram. Into how many pieces, each weighing one decigram, may it be divided ?

Ans. 7 pieces and 0·023 gram will remain.

15. A piece of Swedish filter paper measuring 60 centimetres square, leaves on burning 0·1062 gram of ash. Calculate the amount of ash left on burning filters possessing the following radii : (*a*) 3 centimetres, (*b*) 4 centimetres, (*c*) 5 centimetres, (*d*) 6 centimetres, (*e*) 8 centimetres, (*f*) 10 centimetres.

Ans. (*a*) 0·00083 gram, (*b*) 0·00148 gram, (*c*) 0·00231 gram, (*d*) 0·00333 gram, (*e*) 0·00593 gram, (*f*) 0·00926 gram.

16. A perfectly cylindrical tube 90 millimetres in length holds exactly one gram

of water at 4° C. Calculate its internal diameter. *Ans.* 3·76 m. m.

17. What is the internal diameter of a spherical bulb holding 300 c. c. ?

Ans. 8·305 c. m.

18. A cylindrical graduated tube 15 millimetres in diameter holds 25 c. c. up to the hundredth division. Calculate the value in grams of water at 4° C. of one division. What will be the length between each division ?

Ans. 0·25 gram, 1·4 m. m.

19. The standard pressure at which the volume of a gas is estimated is indicated by the barometric height of 760 m. m. Express the same in inches.

Ans. 29·9218.

20. How many miles are there in 15 kilometres ? *Ans.* 9·321.

21. Reduce 16 litres to U. S. gallons.

Ans. 4·2283 +

22. In 1·5 pints there are how many cubic centimetres.

Ans. 851·44 +

23. The mean height of the barometer in the latitude of Greenwich at the level

of the sea is 30 inches. How many millimetres is this equivalent to?

Ans. 761·985.

24. Reduce 1·5 kilograms to lbs. avoir.

Ans. 3·0693+

25. How many pounds of water having a temperature of 4° C. will a flask hold which has a capacity of 3 litres?

Ans. 6 lbs. and 9·82+oz.

II.

Thermometric Scales.

In the *Centigrade* scale the freezing point is marked 0°, and the boiling point 100°; in *Reaumur's* scale the freezing point is marked 0°, and the boiling point 80°; in *Fahrenheit's* scale the freezing point is marked 32°, and the boiling point 212°. Hence 180° F. are equal to 100° C. or to 80° R.

In the following formulæ for the conversion of the thermometric scales F., C., and R. denote equivalent temperatures expressed in degrees of the three scales:

F. $= \frac{9}{5}$ C. + 32 $= \frac{9}{4}$ R. + 32. [1]

C. $= \frac{5}{4}$ R. $= \frac{5}{9}$ (F. − 32). [2]

R. $= \frac{4}{5}$ C. $= \frac{4}{9}$ (F. − 32). [3]

26. Mercury boils at 350° C. What are the corresponding temperatures on the scales of Fahrenheit and Reaumur?

By [1], F. $= \frac{9}{5} \times 350 + 32 = 662°$.

By [3], R. $= \frac{4}{5} \times 350 = 280°$.

27. Sulphuric acid boils at 338° C. What is the corresponding boiling point on Fahrenheit's scale? *Ans.* 640°·4.

28. Cast-iron melts at 2822° F. and tin at 455° F. What is the difference between their melting points expressed in centigrade degrees? *Ans.* 1315 degrees.

29. Water has been cooled in fine capillary tubes to — 20° C. without freezing. What is the same temperature on the scale of Fahrenheit? *Ans.* —4°.

30. What is the difference in temperature between 72° C. and 72° F.?

Ans. 49°·78 C.

31. The lowest artificial temperature obtained is said to be — 220° F. What is the corresponding temperature on the centigrade scale? *Ans.* —140°.

32. At what point does the same number indicate the same temperature on the Fahrenheit and centigrade thermometers? To what temperature does this point correspond on the scale of Reaumur?

Ans. $-40°$. $-32°$ R.

33. At what point does the same number indicate the same temperature on the thermometers of Fahrenheit and Reaumur? To what temperature does this point correspond on the centigrade scale?

Ans. $-25°{\cdot}6$. $-32°$ C.

III.

Volume of Gases under Varying Pressure.

Mariotte's Law. The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure to which it is exposed.

The principle is expressed by the proportion

$$P' : P :: V : V' \quad [4]$$

in which V and V′ represent the volumes

which are exposed to the pressures of P and P′ respectively. Usually the pressure to which a gas is exposed, is measured by the barometer, so that H and H′ (indicating barometric heights) may be substituted for P and P′ in [4], by which we obtain

$$H' : H :: V : V'. \quad [5]$$

The standard pressure is that indicated by the barometric height of 760 m. m. It can easily be shown that the specific gravity of a given quantity of a gas is directly proportional to the pressure to which it is exposed, and that the weight of a given volume of gas is also directly proportional to the pressure to which it is exposed.

34. A volume of gas was found to be equal to 250 c. c. when the height of the barometer was 742 m. m. What would have been the volume had the barometer stood at 760 m. m. ?

By [5], $760 : 742 :: 250 : V' = Ans.$ 244·08 nearly.

35. A volume of gas measured 467 c. c. when the barometer stood at 756 m. m.

What would it have measured had the barometer stood at 760 m. m.?

Ans. 464·54+

36. A volume of air measured 137 c. c. when the barometer stood at 766 m. m. What would it have measured had the barometer stood at 757 m. m.?

Ans. 138·63 c. c.

37. A volume of hydrogen measuring 195 c. c. when the barometer stood at 740 m. m. was afterwards found to measure 200 c. c. What was the height of the barometer at that time?

Ans. 721·5 m. m.

38. A flask having a capacity of 4·5 litres is filled with a gas when the barometer stood at 755 m. m. What would be the volume of the same gas in c. c. when the barometer stands at 762 m. m.?

Ans. 4458·66+c. c.

39. A volume of hydrogen gas in a bell jar over mercury measured 524 c. c. The mercury in the jar was 54 m. m. above the surface of the mercury in the trough, and the barometer stood at 745 m. m.

What would have been the volume if exposed to the standard pressure alone?

Ans. 476·4 c. c.

40. A volume of air in a bell jar over water measured 975 c. c. The water in the jar was 68 m. m. above the water in the trough, and the barometer stood at 756 m. m. What would have been the volume if exposed to the standard pressure, on the supposition that mercury is 13·6 times heavier than an equal volume of water?

Ans. 963·45+

IV.

Volume of Gases under Varying Temperature.

Law of Charles. The pressure remaining the same, the volume of a given quantity of a gas is directly proportional to its absolute temperature.

A gas expands or contracts 1-273 of its volume at 0° C. for every increase or decrease in temperature of 1° C.; hence if a volume of a gas at 0° C. should have its

temperature lowered through 273°, the contraction would equal the volume. This point (273 below zero C.) is called the *absolute zero*, and temperatures reckoned from this point, *absolute temperatures*. The principle is expressed by the proportion

$$T : T' :: V : V' \quad [6].$$

41. A volume of air measured 475 c. c. at 27°. What would have been its volume at zero?

By [6], $273+27 : 273+0 :: 475 : V'$
$= Ans.$ 432·25.

42. A quantity of hydrogen gas measured 550 c. c. at 15°. What would have been its volume had its temperature been −10°?

$273+15 : 273-10 :: 550 : V' = Ans.$ 502·257.

43. A given weight of air measured 256 c. c. at 34°. What would have been its volume had its temperature been zero?

Ans. 227·648 c. c.

44. A volume of nitrogen measured 3·5 litres at 75°. What would have been its volume had its temperature been 15°?

Ans. 2·9 litres nearly.

45. A volume of gas measured 50 c. c. at 15°. At what temperature would its volume become 44 c. c. ?

Ans. —19·56°.

46. A quantity of gas was measured when its temperature was 12°. At what temperature would its volume be doubled?

Ans. 297°.

47. An open vessel was heated to 819°. What portion of the air which the vessel contained at 0° remained in it?

Ans. $\frac{1}{4}$.

48. An open vessel was heated till one-half of the gas which it contained at 15° was driven out. What was the temperature of the vessel? *Ans.* 303°.

V.

Volume of Gases under Varying Pressure and Temperature.

By combining [5] and [6] we obtain

$$\left.\begin{matrix} H' : H \\ T : T' \end{matrix}\right\} :: V : V' \text{ [7].}$$

49. A volume of oxygen measured 375 c. c. when the barometer stood at 745

m. m., and its temperature was 17°. What would have been the volume at the standard pressure of 760 m. m. and standard temperature of 0°?

By [7] $\left.\begin{matrix} 760 : 745 \\ 273+17 : 273+0 \end{matrix}\right\} :: 375 : V' =$

Ans. 346·05 c. c.

50. A volume of hydrogen at a temperature of 15° measured 2·7 litres when the barometer stood at 752 m. m. What would have been its volume had its temperature been 9°, and the barometer stood at 762 m. m.? Ans. 2·6 litres.

51. The temperature of the air in an open vessel was 11° when the barometer stood at 757 m. m. To what extent would the air expand should the vessel be heated to 1000° when the barometer stood at 764 m. m.?

Ans. 4·44 times its original volume.

Reduce the following volumes of gas to the standard temperature of 0° and 760 m. m.:

52. 18 c. c. having a temperature of 14° and under a pressure of 742 m. m.

Ans. 16·715 c. c.

53. 14 c. c. having a temperature of 11° and under a pressure of 763 m. m.

Ans. 13·51 c. c.

54. 2·5 litres having a temperature of 18° and under a pressure of 748 m. m.

Ans. 2·38 litres.

55. 0·18 c. m. having a temperature of 20° and under a pressure of 764 m. m.

Ans. 0·1686 c. m.

56. A volume of gas whose temperature was 15° measured 1640 cubic inches when the barometer stood at 29·7 inches. What would have been its volume had its temperature been 10° and the height of the barometer 30·2 inches?

Ans. 1584·84 cubic inches.

VI.

Specific Gravity.

The specific gravity of a body is the ratio of its weight to the weight of an equal volume of some substance taken as a standard. Pure water at its maximum density (4° C.) is the standard adopted

for solids and liquids. Gases are compared with hydrogen or air.

57. An empty bottle weighing 3·53 grams weighs 7·67 grams when filled with water, and 7·42 grams when filled with oil; what is the specific gravity of the oil?

$$Ans. \frac{7\cdot42-3\cdot53}{7\cdot67-3\cdot53}=\cdot9355.$$

58. A solid weighing 15·3 grams in air weighs 13·8 grams when immersed in water, what is its specific gravity?

According to the principle of Archimedes a solid immersed in a fluid loses a portion of its weight equal to the weight of the fluid displaced. Hence 15·3—13·8= the weight of a volume of water equal to the volume of the substance.

$$Ans. \frac{15\cdot3}{15\cdot3-13\cdot8}=10\cdot2.$$

59. A mass of lead weighing 16 grams weighs 14·6 grams when in water, when attached to 2 grams of cork and immersed in water weighs 8·6 grams; what is the specific gravity of the cork?

The lead alone loses 1·4 grams, but the lead and cork together lose 16+2—8·6

$=9{\cdot}4$ grams; hence the weight of a volume of water equal to the volume of the cork is $9{\cdot}4-1{\cdot}4=8$ grams.

Ans. $2\div 8={\cdot}25$.

60. A glass bulb weighted with mercury and suspended from one of the scales of a balance weighs in air 73·42 grams, in alcohol 37·996 grams, in water 29·14 grams; what is the specific gravity of the alcohol?

Ans. $\frac{73{\cdot}42-37{\cdot}996}{73{\cdot}42-29{\cdot}14}={\cdot}8$.

61. The weight of 2·3 litres of oxygen at the standard pressure of 760 m. m. and temperature of zero is 3·2885 grams; what is its specific gravity referred to air?*

Ans. $\frac{3{\cdot}2885}{1{\cdot}2932\times 2{\cdot}3}=1{\cdot}1056$.

62. Find the specific gravity of alcohol vapor, referred to air, from the following data obtained by Dumas' method:

Weight of glass globe full of air is 50·804 grams when the barometer stands

---

* The weight of one litre of dry air is 1·2932 grams, of one litre of hydrogen (often used as a standard of weight and called crith) is ·0896 gram.

at 747·5 m. m., and the temperature is 18°. Weight of the globe filled with vapor having a temperature of 167° is 50·824 grams, the height of the barometer at the moment of sealing being 747·6 m. m. The capacity of the globe is 351·5 c. c.

The first step in the above example is to find the weight of the vacuous globe. This is found by subtracting from the weight of the globe full of air, the weight of air contained in the globe, ascertained by calculation from the capacity of the globe, the temperature and pressure of the air and the weight of one c. c. of air under standard conditions.

By [7] we thus reduce 351·5 c. c. of air when the barometer stands at 747·5 m. m., and the temperature is 18° to standard conditions.

$$\left.\begin{matrix} 760 : 747{\cdot}5 \\ 273+18 : 273 \end{matrix}\right\} :: 351{\cdot}5 : V' = 324{\cdot}328$$

and the weight of 324·328 c. c. of air is ·41942 gram. (The weight of one c. c. of air is ·0012932 gram.)

50·804 − ·41942 = 50·38458 = weight of vacuous globe.

The second step is to find the weight of the vapor, which is readily done by subtracting the weight of the vacuous globe from the weight of the globe full of vapor, 50·824—50·38458=·43942 gram =weight of vapor.

The third step is to find the weight of a volume of air equal to that of the vapor, and having the same temperature and under the same pressure. We must now find the capacity of the globe, taking into account the expansion due to the increase of temperature, which causes no appreciable error when the increase is small. One c. c. of glass increases ·00003 c. c. when the temperature is raised one degree; hence 351·5 c. c. of glass at a temperature of 167° become ·00003 × 351·5 × 167 + 351·5 = 353·261 c. c. Proceeding as in the first step,

$$\left.\begin{matrix} 760 : 747{\cdot}6 \\ 273+167 : 273 \end{matrix}\right\} :: 353{\cdot}269 : V' = 215{\cdot}9328$$

and 215·9328 c. c. of air weigh ·279244 gram. The final step is to divide the weight of the vapor by the weight of the air, ·43942 ÷ ·279244 = 1·574, which is the specific gravity of alcohol vapor.

63. What is the weight of 6·5 c. c. of iron having a specific gravity of 7·84?

The weight of 6·5 c. c. of water is 6·5 grams; hence the weight of an equal volume of iron having a specific gravity of 7·84 is $6·5 \times 7·84 = 50·96$ grams.

64. What is the specific gravity of lead if 17·4 grams weigh 15·8 grams when under water? *Ans.* 11·5.

65. A solid weighing 18·5 grams weighs when under water 16·4 grams, and when under naphtha 16·72 grams. What is the specific gravity of the naphtha?

Ans. ·848.

66. Three litres of marsh gas weigh 2·15 grams. What is its specific gravity, hydrogen being the standard?

Ans. 8.

67. An empty bottle weighing 3·5305 grams weighs when filled with pure water 7·6722 grams, when filled with sea-water 7·7849 grams. What is the specific gravity of the sea-water?

Ans. 1·0272.

68. A bottle filled with a liquid weighs 11·4692 grams, with water weighs 7·6649

grams, when empty weighs 3·5312 grams. What is the specific gravity of the liquid ?

Ans. 1·92.

69. A bottle holds 2·545 grams of alcohol, 42·74 grams of mercury, and 5·829 grams of sulphuric acid. Find the specific gravity of mercury and of sulphuric acid, the density of alcohol being ·8095.

Ans. 13·596 and 1·854.

70. What is the weight of 40 c. c. of sulphuric acid having a specific gravity of 1·8 ? *Ans.* 72 grams.

71. What is the volume of 3·6 kilos. of alcohol having a specific gravity of ·8 ?

Ans. 4·5 litres.

72. From data given in problem 64, find the weight of 2·5 cubic feet of lead. The weight of a cubic foot of water is 62·425 lbs. *Ans.* 1794·718 lbs.

73. A piece of metal weighs 3·7395 grams in air, 1·578 in water, and 2·2896 in another liquid. What is the specific gravity of the metal and of the liquid ?

Ans. Metal 1·73; liquid ·67.

74. Find the specific gravity of wood from the following data: weight of wood

4 grams, of a silver sinker 10 grams, of wood and sinker under water 8·5 grams, specific gravity of silver 10·5.

Ans. ·8793.

75. A sphere of platinum weighs in air 84 grams, in mercury 22·6. What is the specific gravity of platinum, mercury being the standard? Water being the standard, what is the specific gravity of the platinum, that of mercury being 13·6?

Ans. 1·368, and 18·6.

76. Two litres of hydrogen sulphide weigh 3·0442 grams. What is its specific gravity referred to air?

Ans. 1·177.

77. What is the weight of 1500 c. c. of a gas at the standard pressure of 760 m. m. and temperature of zero whose specific gravity referred to hydrogen is 14? *Ans.* 1·8816 grams.

78. What is the volume of 3·0571 grams of a gas whose specific gravity referred to air is ·591?

Ans. 4 litres.

79. The specific gravity of oxygen under standard conditions is 1·1056

(air=1). What is its specific gravity when the barometer stands at 745 m. m.?

Ans. 1·0838.

80. The specific gravity of ammonia gas under standard conditions is ·591. What is its specific gravity when the barometer stands at 750 m. m.?

Ans. ·5832.

81. The specific gravity of chlorine is 2·45 under standard conditions. What is the barometric height when the specific gravity is 2·40?

Ans. 744·5 m. m. nearly.

82. One litre of hydrogen under standard conditions weighs ·0896 gram. What is the weight of one litre when the barometer stands at 740 m. m.?

Ans. ·08724 gram.

83. One litre of air under standard conditions weighs 1·2932 grams. What is the weight of 2·5 litres when the barometer stands at 755 m. m.?

Ans. 3·21173 grams.

84. Under a pressure of 745 m. m., 1500 c. c. of chlorine weigh 4·67174 grams.

What is the weight of one litre under standard pressure ?

Ans. 3·1772 grams.

85. Under standard conditions, one litre of oxygen weighs 1·4336 grams. What is the pressure when one litre weighs 1·29024 grams ?

Ans. 684 m. m.

86. Under a pressure of 745 m. m., 1500 c. c. of a gas weigh 1·9762 grams. What is the weight per litre under standard pressure ? *Ans.* 1·344 grams.

87. The specific gravity of oxygen referred to hydrogen is 16 at zero. What is its specific gravity when its temperature is 27° ? *Ans.* 14·56.

88. If the specific gravity of a gas is 22 at zero, what will be its specific gravity at 819° ? *Ans.* 5·5.

89. If the specific gravity of a gas is 32 at the temperature of 15°, at what temperature will it have a specific gravity of 28·16 ? *Ans.* 54°·327.

90. What is the specific gravity of oxygen when the barometer stands at 760 m. m. and its temperature is zero, if its

specific gravity is 14·7648 when the barometer stands at 745 m. m. and its temperature is 17° ? *Ans.* 16.

91. The specific gravity of a gas is 32 when the barometer is at 760 m. m. and the thermometer at zero. What will be its specific gravity if the barometer stands at 750 m. m. and the thermometer at 11° ?

Ans. 30·35.

92. Find the specific gravity of camphor vapor referred to air, from the following data: weight of glass globe full of air 50·134 grams when the barometer stands at 742 m. m. and the temperature is 13·5°; weight of the globe filled with vapor having a temperature of 244° 50·842 grams, the height of the barometer at the moment of sealing being 742 m. m.; capacity of the globe 295 c. c.

Ans. 5·371.

93. From the data given in the 62d problem find the specific gravity of alcohol vapor, hydrogen being taken as the standard. *Ans.* 22·712.

VII.

Molecular Weight of Gases.

The molecular weight of a perfect gas or vapor is equal to twice its specific gravity referred to hydrogen. The weight of gases is taken at the standard pressure of 760 m. m. and temperature of zero. The weight of one litre (1000 c. c.) of dry air is 1·2932 grams. The weight of one litre hydrogen (often used as a unit of weight and called *crith*) is ·0896 gram.

94. What is the molecular weight of marsh gas, three litres of which weigh 2·15 grams?

$$Ans. \frac{2{\cdot}15}{{\cdot}0896 \times 3} \times 2 = 16.$$

Determine the molecular weights of the following gases from the data annexed:

95. Nitrogen, 2 litres weigh 2·5088 grams. *Ans.* 28.

96. Sulphurous oxide, one litre weighs 2·8672 grams. *Ans.* 64.

97. Carbon monoxide, 1500 c. c. weigh 1·8816 grams. *Ans.* 28.

98. Carbon dioxide, 500 c. c. weigh ·9856 grams. *Ans.* 44.

99. A quantity of gas measuring 5·04675 litres when the temperature is 15° and pressure 740 m. m. weighs 7·616 grams. What is its molecular weight?

Ans. 34 (very nearly).

100. The specific gravity of a gas was 31·1707 when its temperature was 11°, and under a pressure of 750 m. m. What is its molecular weight? *Ans.* 64.

101. From data given in problems 84 and 85, find the molecular weights of chlorine and oxygen. *Ans.* 70·92 and 32.

VIII.

To Find Atomic Weights.

102. Find the atomic weight of hydrogen from the following data. In the second column is given the molecular weight of the substances, and in the third column the weight of hydrogen in the molecules:

Hydrochloric Acid	36·5	1
Hydrobromic Acid	81	1

Hydrogen Gas	2	2
Water	18	2
Formic Acid	46	2
Phosphoretted Hydrogen	34	3
Ammonia Gas	17	3
Acetic Acid	60	4
Olefiant Gas	28	4
Marsh Gas	16	4
Alcohol	46	6
Ether	74	10

It is inferred that as 1 is the weight of the smallest mass of hydrogen known to exist in a molecule of any substance, that this smallest mass is the atom, and hence that 1 is the atomic weight of hydrogen.

103. Find the atomic weight of carbon and the number of atoms of carbon in each molecule of the substance named:

	Molecular weight.	Weight of Carbon in Molecule.
(*a*) Carbon Dioxide	44	12
(*b*) Carbon Disulphide	76	12
(*c*) Olefiant Gas	28	24
(*d*) Alcohol	46	24
(*e*) Propylic Hydride	44	36
(*f*) Ether	74	48
(*g*) Amylic Hydride	72	60

Ans. Atomic weight of carbon is 12.

(*a*) and (*b*) have each one atom of carbon, (*c*) and (*d*) each two atoms, (*e*) three atoms, (*f*) four atoms, (*g*) five atoms.

104. Find the atomic weight of oxygen and the number of atoms of oxygen in each molecule of the following substances from the annexed data:

	Molecular weight.	Weight of Oxygen in Molecule.
(*a*) Water	18	16
(*b*) Carbon Monoxide	28	16
(*c*) Carbon Dioxide	44	32
(*d*) Phosphoric Oxide	142	80
(*e*) Sulphuric Oxide	80	48
(*f*) Nitric Acid	63	48
(*g*) Sulphuric Acid	98	64
(*h*) Sodic Bisulphate	222	112

Ans. Atomic weight of oxygen is 16.

(*a*) and (*b*) have each one atom of oxygen, (*c*) two atoms, (*d*) five atoms, (*e*) and (*f*) each three atoms, (*g*) four atoms, and (*h*) seven atoms.

105. In 100 parts of lime (calcic oxide) there are 71·43 parts of calcium and 28·57 parts of oxygen. The atomic weight of oxygen is 16, and there is reason to believe that each molecule of lime is a

group of two atoms, one each of calcium and oxygen. What is the atomic weight of calcium ?

Ans. 28·57 : 71·43 :: 16 : 40 = weight of the one atom of calcium.

106. In 100 parts of calcic chloride there are 36·03 parts of calcium and 63·97 parts of chlorine. The atomic weight of calcium is 40, and there is reason to believe that each molecule of the calcic chloride is a group of three atoms, one of calcium and two of chlorine. What is the atomic weight of chlorine ?

Ans. 35·5.

107. In 100 parts of stannic chloride there are 54·61 parts of chlorine and 45·39 parts of tin. The atomic weight of chlorine is 35·5. What is the atomic weight of tin, on the supposition that each molecule of stannic chloride is a group of five atoms, one of tin and four of chlorine ? *Ans.* 118.

108. In 100 parts of stannic sulphide there are 35·17 parts of sulphur and 64·83 parts of tin. The atomic weight of tin is 118. What is the atomic weight of

sulphur, on the supposition that each molecule of stannic sulphide is a group of three atoms, one of tin and two of sulphur? *Ans.* 32.

109. Calculate the atomic weight of phosphorus from the following data: In 100 parts of phosphoric oxide there are 43·66 parts of phosphorus and 56·34 parts of oxygen. Each molecule is a group of seven atoms, two of phosphorus and five of oxygen, and the atomic weight of oxygen is 16.

Ans. 31.

110. A compound of silver and chlorine, weighing 121·4993 grams, was produced by heating 91·462 grams of silver in a stream of chlorine gas. What is the atomic weight of silver, on the supposition that one atom of silver unites with one atom of chlorine?

Ans. 108·09.

111. Copper oxide when heated in a stream of hydrogen lost 59·789 grams of oxygen and yielded 67·282 grams of water. Calculate the atomic weight of oxygen on the supposition that one atom of

oxygen unites with two atoms of hydrogen to form a molecule of water.

Ans. 15·959 very nearly.

112. A compound of mercury and oxygen, weighing 118·3938 grams yielded 109·6308 grams of mercury. Calculate the atomic weight of mercury on the supposition that one atom of oxygen unites with one atom of mercury to form a molecule of the compound. *Ans.* 200·17.

113. Find the atomic weight of silver from the following data: molecular weight of silver chloride 143·5 : in 100 parts of silver chloride there are 75·26 parts (very nearly) of silver : specific heat of silver ·057.*

Weight of silver in the molecule is $143{\cdot}5 \times 75{\cdot}26 \div 100 = 108$, which may represent the weight of one, two, three or more atoms. Divide 6·34 by ·057 (the specific heat of silver) and we will obtain approximately the atomic weight of silver.

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* It has been found that the product of the atomic weight of an elementary solid by its specific heat varies from 5·6 to 6·9—the mean being very nearly 6·34. Boron and carbon are exceptions. See Table V. in the Appendix.

6·34÷·057=111, which shows that 108 represents the weight of one atom of silver.

114. Find the atomic weight of lead from the following data: molecular weight of lead sulphide 249 : in 100 parts of lead sulphide there are 83·13 parts of lead; specific heat of lead ·0314.

Ans. 207.

115. The molecular weight of arseniuretted hydrogen is 78. In 100 parts there are 96·15 parts of arsenic, and the specific heat of arsenic is ·0814. What is the atomic weight of arsenic? *Ans.* 75.

116. The molecular weight of carbon disulphide is 76, and 100 parts yield 84·21 parts of sulphur; the specific heat of sulphur is ·178. What is the atomic weight of sulphur, and how many atoms of sulphur in a molecule of the carbon disulphide?

Ans. Atomic weight 32, and number of atoms of sulphur in the molecule 2.

117. From the following data find the atomic weight of sodium and the number

of atoms each of sodium and chlorine in a molecule of sodium chloride (common salt): in 100 parts of sodium chloride there are 60·68 parts of chlorine and 39·32 parts of sodium; atomic weight of chlorine 35·5; specific heat of sodium ·293.

Ans. Atomic weight of sodium 23, and a molecule of sodium chloride contains one atom each of chlorine and sodium.

118. From the following data, find the atomic weight of manganese and the number of atoms in the compound analyzed: an analysis of an oxide of manganese yielded 69·62 parts of manganese and 30·38 parts of oxygen in 100; atomic weight of oxygen 16; specific heat of manganese ·1217.

Ans. Atomic weight of manganese 55. Number of atoms in a molecule of the compound five, three of oxygen and two of manganese.

IX.

Calculation of Molecular Weights from the Symbol.

119. What is the molecular weight of zinc sulphate $ZnSO_4$? The molecular weight of a compound is equal to the sum of the weights of the atoms composing it. $ZnSO_4$ has a molecular weight 161·2. (161·2 being equal to $65·2+32+4\times16$).

The atomic weights of the elements are given in Table IV. in the Appendix.

Find the molecular weights of the following compounds by means of the annexed symbols:

120. Water, H_2O. *Ans.* 18.

121. Phosphoric Oxide, P_2O_5. *Ans.* 142.

122. Borax, $Na_2B_4O_7$. *Ans.* 202.

123. Potassium Chlorate, $KClO_3$. *Ans.* 122·6.

124. Lead Sulphate, $PbSO_4$. *Ans.* 303.

125. Kakodyl, $C_4H_{12}As_2$. *Ans.* 210.

126. Ethylic Silicate, $C_8H_{20}O_4Si$.
Ans. 208.

127. Kreatin, $C_4H_9N_3O_2 + H_2O$.
Ans. 149.

128. Gypsum, $CaSO_4 + 2H_2O$.
Ans. 172.

129. Alum, $K_2Al_24SO_4 + 24H_2O$.
Ans. 948·2.

X.

Symbol, Weight and Volume.

130. What is the weight of one litre of carbon dioxide at standard pressure and temperature? Symbol is CO_2.

The molecular weight of carbon dioxide $(12 + 2 \times 16)$ is 44, and hence its specific gravity referred to hydrogen is 22. One litre of hydrogen weighs ·0896 gram, and the weight of one litre of carbon dioxide is $·0896 \times 22 = 1·9712$ grams.

Calculate the weight of the following gases at standard pressure and temperature:

131. Two litres of hydrochloric acid gas. Symbol HCl. *Ans.* 3·27+ grams.

132. 1500 c. c. of hydrogen sulphide. Symbol H_2S.

Ans. 2·2848 grams.

133. 250 c. c. of chlorine. Symbol Cl_2.

Ans. ·7952 grams.

134. Five litres of ethene. Symbol C_2H_4. *Ans.* 6·272 grams.

135. What is the weight of five litres of alcohol vapor having a temperature of 127° and under a pressure of 750 m. m. ? Symbol of alcohol C_2H_6O.

Ans. 6·94 grams.

136. What is the volume of a kilogram of carbon monoxide (CO) at the standard temperature and pressure?

Ans. 797·114 litres.

137. What is the volume of 225 grams of hydrogen sulphide (H_2S) at the standard temperature and pressure ?

Ans. 147·715 litres.

138. What is the volume of 20 grams of carbon dioxide (CO_2) at the standard temperature and pressure?

Ans. 10·146 litres.

139. What is the volume of 82·88 grams of the vapor of vinic ether ($C_4H_{10}O$) at

the temperature of 147°, and under a pressure of 740 m. m.?

Ans. 39·5 litres.

XI.

Symbol and Composition.

140. Calculate the percentage composition of water, H_2O.

First find the molecular weight of water;

Weight of atoms hydrogen = 2.
" " " oxygen = 16.
Molecular weight of water = 18.

Then for every 18 parts of water there must be 2 parts of hydrogen and 16 parts of oxygen, and the percentage composition or amount of each constituent in 100 parts of the compound is readily found by the proportion

18 : 2 :: 100 : x = 11·11 = the percentage of hydrogen.

18 : 16 :: 100 : x = 88·89 = the percentage of oxygen.

The following proportion of general application may be readily deduced:

$$m : w :: M : W. \quad [8].$$

In which m = molecular weight of the substance; w = weight of the atoms of each element or constituent of the molecule; M = weight of the substance; W = weight of each element or constituent.

Calculate the percentage composition of the following compounds:

141. Carbon dioxide, CO_2.

Ans. Carbon 27·27. Oxygen 72·73.

142. Ammonia, H_3N.

Ans. Hydrogen 17·65. Nitrogen 82·35.

143. Ferric Oxide, Fe_2O_3.

Ans. Iron 70. Oxygen 30.

144. Alcohol, C_2H_6O.

Ans. Carbon 52.18. Hydrogen 13·04. Oxygen 34·78.

145. Acetic acid, $C_2H_4O_2$.

Ans. Carbon 40. Hydrogen 6·67. Oxygen 53·33.

146. Calcium sulphate, $CaSO_4$.

Ans. Calcium 29.41. Sulphur 23·53. Oxygen 47·06.

147. Cream of tartar, $KH_5C_4O_6$.

Ans. Potassium 20·79. Hydrogen 2·66. Carbon 25·52. Oxygen 51·03.

148. Ferrous Sulphate, $FeSO_4 + 7H_2O$.

Ans. Iron 20·15. Sulphur 11·51. Oxygen 23·02. Water 45·32.

149. Common alum, $K_2Al_24SO_4 + 24H_2O$.

Ans. Potassium 8·25. Aluminum 5·70. Sulphur 13·50. Oxygen 26·99. Water 45·56.

150. How much iodine can be obtained from 236 grams of potassic iodide (KI)?

Ans. 180·37 grams.

151. How many grams of oxygen and of hydrogen can be obtained by the decomposition of 27 grams of water (H_2O)?

Ans. 24 grams of oxygen and 3 of hydrogen.

152. How many grams of oxygen can be obtained by the decomposition of 100 grams of mercuric oxide (HgO)?

Ans. 7·407 grams.

153. How many pounds of phospho-

rus in 265 pounds of calcic phosphate ($Ca_3P_2O_8$)?

Ans. 53 pounds.

154. It is required to find the weight of iron in 1000 kilograms of ferric oxide (Fe_2O_3). *Ans.* 700 kilos.

155. How many grams of potassic chlorate ($KClO_3$) are needed to produce, by decomposition, 100 grams of oxygen?

Ans. 255·4 grams.

156. How many pounds of pure limestone ($CaCO_3$) are needed to produce one ton of quicklime (CaO)?

Ans. 3571·428 pounds.

157. How many grams of copper can be obtained from 1337 grams of cupric sulphate ($CuSO_4+6H_2O$)?

Ans. 317 grams.

158. If 1337 grams of cupric sulphate yield 317 grams of copper, and the atomic weight of the copper in one molecule is 63·4, what is the molecular weight of cupric sulphate? *Ans.* 267·4.

159. If 1337 grams of cupric sulphate yield 317 grams of copper, and its molecular weight is 267·4, how many atoms

of copper are there in a molecule of the sulphate? *Ans.* 1.

160. How much potassic iodide (KI) will be required to yield 78 grams of iodine? *Ans.* 104·43 grams.

161. Ferric oxide contains 30 per cent. of oxygen, and its molecule three atoms of oxygen. What is its molecular weight? *Ans.* 160.

162. Sodium chloride (common salt) contains 39·32 per cent. of sodium, and its molecular weight is 58·5. What is the atomic weight of sodium, on the supposition that there is but one atom of sodium in the molecule of salt? *Ans.* 23.

163. By heating 15 grams of pure silver in a stream of chlorine, 19·9306 grams of silver chloride are produced. The weight of the atoms of silver in a molecule of silver chloride is 108. What is the molecular weight of silver chloride and the number of atoms of chlorine in a molecule?

Ans. Molecular weight 143·5. No. of atoms of chlorine 1.

164. One gram of water (H_2O) will

yield how many cubic centimetres of hydrogen and oxygen, having a temperature of 20° when the barometer stands at 765 m. m.? The specific gravity of oxygen referred to hydrogen is 16.

By [8], one gram of water will yield ·1111 gram of hydrogen and ·8889 gram of oxygen. The volume of ·1111 gram of hydrogen at 0°, and under a pressure of 760 m. m. is found (·1111 ÷ ·0000896) to be equal to 1240 c. c. The volume which the 1240 c. c. of hydrogen will occupy when the temperature is 20°, and under a pressure of 765 m. m., is found by [7].

$$\left.\begin{matrix} 273 : 273+20 \\ 765 : 760 \end{matrix}\right\} :: 1240 : V' = 1322{\cdot}144 \text{ c. c.}$$

The volume of ·8889 gram of oxygen at 0°, and under a pressure of 760 m. m., is found (·8889 ÷ (·0000896 × 16)) to be equal to 620 c. c. The volume which the 620 c. c. of oxygen will occupy when the temperature is 20°. and under a pressure of 765 m. m., is found by [7] as above, to be equal to 661·072 c. c.

Ans. Hydrogen 1322·144 c. c. Oxygen 661.072 c. c.

165. How many c. c. of chlorine at a temperature of 15°, and under a pressure of 770 m. m., can be obtained from 15 grams of silver chloride (AgCl)? The specific gravity of chlorine referred to hydrogen is 35·5. *Ans.* 1214·708 c. c.

166. How many grams of mercuric oxide (HgO) can be obtained by the union of mercury with 1500 c. c. of oxygen, measured at a temperature of 18° when the barometer stands at 755 m. m.?

Ans. 27·055 grams.

167. How many grams of mercury, and how many litres of chlorine measured at a temperature of 15° when the barometer stands at 770 m. m., are consumed in the manufacture of 100 grams of corrosive sublimate ($HgCl_2$)?

Ans. 8·576 litres of chlorine. 73·80 grams of mercury.

XII.

To Find the Symbol of a Compound.

168. The specific gravity of the vapor of acetic acid is 30. In 100 parts of the

acid there are 40 parts of carbon, 6·67 parts of hydrogen and 53·33 parts of oxygen. What is the symbol of acetic acid?

The molecular weight is $(30 \times 2) = 60$.

By [8], 60 : w :: 100 : 40 . w = 24 = weight of carbon atoms.

60 : w :: 100 : 6·67 . w = 4 = weight of hydrogen atoms.

60 : w :: 100 : 53·33 . w = 32 = weight of oxygen atoms.

$24 \div 12 = 2$ = the number of atoms of carbon in a molecule.

$4 \div 1 = 4$ = the number of atoms of hydrogen in a molecule.

$32 \div 16 = 2$ = the number of atoms of oxygen in a molecule.

Hence the symbol is $C_2H_4O_2$.

169. The specific gravity of steam is 9. The percentage composition of water is hydrogen 11·11, oxygen 88·89. What is the symbol of water? *Ans.* H_2O.

170. The specific gravity of alcohol vapor is 23. In 100 parts there are 52·18 parts of carbon, 13·04 parts of hydrogen and 34·78 parts of oxygen. What is the symbol of alcohol? *Ans.* C_2H_6O.

171. The percentage composition of ammonia is nitrogen 82·353, hydrogen 17·647. Its specific gravity is 8·5. What is its symbol? *Ans.* H_3N.

172. The specific gravity of the vapor of ethylene chloride is 49·5, and its percentage composition is carbon 24·24, hydrogen 4·04, chlorine 71·72. What is its symbol? *Ans.* $C_2H_4Cl_2$.

173. Calculate the symbol of stannic chloro-triethide from the following data: percentage composition, chlorine 14·76, carbon 29·94, hydrogen 6·24, tin 49·06, specific gravity of vapor 120·25.

Ans. $ClC_6H_{15}Sn$.

174. Calculate the symbol of ethylic silicate from the following data: specific gravity of vapor 104; percentage composition, carbon 46·15, hydrogen 9·62, oxygen 30·77, silicon 13·46.

Ans. $C_8H_{20}O_4Si$.

175. In 100 parts of a compound of manganese and oxygen there are 63·22 parts of manganese, and 36·78 parts of oxygen. What is the simplest symbol possible?

From Table IV. in the Appendix, the atomic weights of manganese and oxygen are found to be 55 and 16 respectively. $63{\cdot}22 \div 55 = 1{\cdot}149$, and $36{\cdot}78 \div 16 = 2{\cdot}299$. As $1{\cdot}149 : 2{\cdot}299 :: 1 : 2$, the simplest ratio between the number of manganese and oxygen atoms is 1 : 2; hence the simplest symbol is MnO_2.

176. A compound of iron and oxygen yielded a percentage composition of iron 70, and oxygen 30 per cent. What is its simplest symbol?

Ans. Fe_2O_3.

177. The percentage composition of ammonic chloride is, nitrogen 26·17, hydrogen 7·48, chlorine 66·35. What is the simplest symbol possible?

Ans. NH_4Cl.

178. Find the simplest symbol for acid potassic carbonate from the following data: percentage composition, hydrogen 1, potassium 39·06, carbon 11·99, oxygen 47·95.

Ans. $HKCO_3$.

179. In 100 parts of sodic sulphate there are 32·39 parts of sodium, 22·54

parts of sulphur, and 45·07 parts of oxygen. What is its simplest symbol?

Ans. Na_2SO_4.

180. Calcic phosphate has in 100 parts 38·71 parts of calcium, 20·00 parts of phosphorus, and 41·29 parts of oxygen, What is its simplest symbol?

Ans. $Ca_3P_2O_8$.

181. In 100 parts of crystallized ferrous sulphate there are 20·15 parts of iron, 11·51 parts of sulphur, 23·02 parts of oxygen, and 45·32 parts of water. What is its simplest symbol?

Ans. $FeSO_4 + 7H_2O$.

182. What is the simplest symbol of morphia, its percentage composition being carbon 71·58, hydrogen 6·66, nitrogen 4·91, oxygen 16·85?

Ans. $C_{17}H_{19}NO_3$.

183. On analysis, 18 grams of a compound of iron and sulphur yielded 8·4 grams of iron and 9·6 grams of sulphur. What is its simplest symbol?

Ans. FeS_2.

184. On analysis, 48 grams of a compound yielded 37·21 grams of lead, 2·16

grams of carbon, and 8·63 grams of oxygen. What is its simplest symbol?

Ans. $PbCO_3$.

185. What is the simplest symbol of a substance, 27 grams of which, on analysis, yielded 2·64 grams of magnesium, 3·51 grams of sulphur, 7·02 grams of oxygen, and 13·83 grams of water?

Ans. $MgSO_4 + 7H_2O$.

XIII.

Equation, Weight and Volume.

186. How much nitric acid (HNO_3) is required to produce 150 grams of copper nitrate (CuN_2O_6)? The reaction is expressed by the equation,

$$3Cu + 8HNO_3 = 3CuN_2O_6 + 4H_2O + 2NO.$$

Since the molecular weights represent the relative weights of the substances used, the same ratio exists between the weight of the molecules ($3 \times 187{\cdot}4$) of

copper nitrate, and the weight of the molecules (8×63) of nitric acid as exists between the weight of copper nitrate and of nitric acid.

$$3 \times 187{\cdot}4 : 8 \times 63 :: 150 : x = Ans.$$

134·47 grams.

The following proportion is easily deduced:

$$n\,m : n'\,m' :: W : W', \quad [9]$$

In which n represents the number of molecules, and m the molecular weight of the substance given, n′ the number of molecules, and m′ the molecular weight of the substance required, W the weight of the substance given, and W′ the weight of the substance required.

187. How many grams of zinc sulphate ($ZnSO_4$) can be obtained by the action of 200 grams of sulphuric acid (H_2SO_4) upon zinc? The reaction is expressed by the equation,

$$Zn + H_2SO_4 = ZnSO_4 + H_2.$$

Ans. 328·98 grams.

188. Nitric acid (HNO_3) is prepared by the action of sulphuric acid (H_2SO_4)

upon potassium nitrate (KNO_3). The following equation expresses the reaction:

$$KNO_3 + H_2SO_4 = HNO_3 + HKSO_4.$$

Calculate (*a*) how much nitric acid may be produced from 500 grams of potassium nitrate, (*b*) how much sulphuric acid would be required to decompose the 500 grams of potassium nitrate, and (*c*) how much acid potassium sulphate ($HKSO_4$) would be produced.

Ans. (*a*) 311·57 + grams, (*b*) 484·66 + grams, (*c*) 673·09 + grams.

189. How many grams of silver and of nitric acid (HNO_3) are required to produce 240 grams of silver nitrate ($AgNO_3$)? The equation is,

$$3Ag_2 + 8HNO_3 = 6AgNO_3 + 4H_2O + 2NO.$$

Ans. 152·47 grams of silver and 118·588 grams of nitric acid.

190. 75 grams of ferrous sulphide (FeS) treated with sulphuric acid (H_2SO_4) will yield how many grams of ferrous sul-

phate ($FeSO_4$) and of hydrogen sulphide (H_2S)? How many grams of sulphuric acid will be required?

$$FeS + H_2SO_4 = FeSO_4 + H_2S.$$

Ans. 129·545 grams of ferrous sulphate, 28·977 grams of hydrogen sulphide, 83·523 grams of sulphuric acid.

191. A solution contains 30 grams of silver nitrate ($AgNO_3$). How much common salt ($NaCl$) is required to decompose the silver nitrate, and how much silver chloride ($AgCl$) is produced?

$$AgNO_3 + NaCl = AgCl + NaNO.$$

Ans. 10·32 grams of salt, and 25·32 grams of silver chloride.

192. How many grams of sulphuric acid (H_2SO_4) and of nitre (KNO_3) are required to make 250 grams of nitric acid? For equation see problem 188.

Ans. 388·9 grams of sulphuric acid and 401·2 grams of nitre.

193. How much hydrochloric acid gas (HCl) can be obtained by treating one kilogram of common salt ($NaCl$) with

sulphuric acid (H_2SO_4)? How much sulphuric acid will be needed?

$$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl.$$

Ans. 623·93 grams of hydrochloric acid gas, and 837·6 grams of sulphuric acid.

By adopting the crith (weight of one litre of hydrogen = ·0896 gram) as the unit of weight for gases and hydrogen as the standard for specific gravity, we obtain

$$\frac{W}{\cdot 0896} = V \times \text{specific gravity},$$

in which W = weight in grams, and V = volume in litres. In the proportion n m : n′ m′ :: W : W′, if we divide the third and fourth terms by ·0896, and the substitute for the fourth term its value as found above and for m′ its value (2 × specific gravity) we easily deduce the proportion

$$n\ m\ :\ 2\ n' :: \frac{W}{\cdot 0896} : V, \quad [10]$$

in which n represents the number of molecules, and m the molecular weight of the substance given; n′ the number

of molecules of the required gaseous substance; W the weight in grams of the given substance, and V the volume in litres of the required gas.*

194. How many litres of hydrochloric acid gas (HCl) can be made by the use of 575 grams of common salt (NaCl)?

$$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl.$$

By [10] $2 \times 58{\cdot}5 : 2 \times 2 :: \frac{575}{{\cdot}0896} : V =$

Ans. 219·48 litres.

195. How many litres of hydrogen phosphide (H_3P) can be made by the use of 250 grams of calcium phosphide (Ca_3P_2)?

$$Ca_3P_2 + 6HCl = 3CaCl_2 + 2H_3P.$$

Ans. 61·323 litres.

196. How many litres of hydrogen arsenide (H_3As) can be made with 640 grams of zinc arsenide?

$$Zn_3As_2 + 6HCl = 3ZnCl_2 + 2H_3As.$$

Ans. 82·674+litres.

197. How many litres of hydrogen and

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* All gases are supposed to be at the standard temperature and under standard pressure, unless otherwise stated.

of oxygen are necessary to produce ten cubic centimetres of water (H_2O) ?

$$2H_2 + O_2 = 2H_2O.$$

Ans. 12·4 litres of hydrogen, and 6·2 litres of oxygen.

198. By the combustion of one cubic centimetre of ether ($C_4H_{10}O$) having a specific gravity of ·715, how many c. c. of carbon dioxide (CO_2) and of aqueous vapor (H_2O) are produced, and how much oxygen is consumed?

$$C_4H_{10}O + 6O_2 = 4CO_2 + 5H_2O.$$

Ans. 862·693 c. c. of carbon dioxide,
1294·039 c. c. of oxygen,
1078·366 c. c. of aqueous vapor.

199. How many litres of hydrochloric acid gas (HCl) and of oxygen can be made by the use of 875 grams of water (H_2O) ? How many litres of chlorine are required?

$$2H_2O = 2Cl_2 = 4HCl + O_2.$$

Ans. 2170·1388 litres of hydrochloric acid,
542·5347 litres of oxygen,
1085·0694 litres of chlorine.

200. How many litres of oxygen are required to burn (i. e. unite with) 1·5 kilo-

grams of alcohol (C_2H_6O) and how many litres of carbon dioxide (CO_2) and of aqueous vapor (H_2O) are formed by the combustion?

$$C_2H_6O + 3O_2 = 2CO_2 + 3H_2O.$$

Ans. 2183·618 litres of oxygen,
1455·745 litres of carbon dioxide,
2183·618 litres of aqueous vapor.

201. How many litres of air are necessary to burn 15 grams of benzole (C_6H_6)? Composition of air is, oxygen 20·96, and nitrogen 79·04 volumes in 100.

$$2C_6H_6 + 15O_2 = 12CO_2 + 6H_2O.$$

Ans. 105·889 litres.

202. How many grams of chalk ($CaCO_3$) are required to yield 15 litres of carbon dioxide (CO_2)?

$$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2.$$

Ans. 67·2 grams.

203. How many grams of common salt (NaCl) are required to make 520 litres of hydrochloric acid gas (HCl)? For equation see problem 194.

Ans. 1362·816 grams.

204. How many grams of zinc and how

many of pure sulphuric acid (H_2SO_4) are required to make 1875 c.c. of hydrogen? For equation see problem 187.

Ans. 5·4768 grams of zinc, 8·232 grams of sulphuric acid.

205. How many litres of oxygen are required to burn two litres of alcohol vapor (C_2H_6O) and how many litres of carbon dioxide (CO_2) and of aqueous vapor (H_2O) are produced?

$$C_2H_6O + 3O_2 = 2CO_2 + 3H_2O.$$

From the equation it appears that for every one molecule of alcohol vapor consumed there are three molecules of oxygen used, and two molecules of carbon dioxide and three of aqueous vapor produced. As "equal volumes of all gases contain the same number of molecules," it follows the volumes are proportioned to the number of molecules. Hence for every two litres of alcohol vapor, there are required six litres of oxygen, and there are produced four litres of carbon dioxide and six of aqueous vapor.

206. How many litres of benzole vapor (C_6H_6) are required to produce by com-

bustion 24 litres of carbon dioxide (CO_2), and how much aqueous vapor (H_2O) is produced and how many litres of oxygen are consumed? For equation see problem 201.

Ans. 4 litres of benzole vapor,
12 litres of aqueous vapor,
30 litres of oxygen.

207. By the burning of 6 litres of carbon monoxide (CO), how many litres of oxygen are consumed and how many of carbon dioxide (CO_2) are produced?

$$2CO + O_2 = 2CO_2.$$

Ans. 3 litres of oxygen, 6 litres of carbon dioxide.

208. Ten litres of hydrogen in burning will require how many litres of oxygen and produce how many litres of aqueous vapor (H_2O)?

$$2H_2 + O_2 = 2H_2O.$$

Ans. 5 litres of oxygen, 10 litres of aqueous vapor.

209. 250 c.c. of chlorine are mixed with 150 c.c. of hydrogen. How many c.c. of hydrochloric acid gas (HCl) are

produced, which gas remains in excess and what is its volume?

$$H_2 + Cl_2 = 2HCl.$$

Ans. 300 c. c. of HCl, 100 c. c. of Cl.

210. How many c. c. of hydrogen and of nitrogen can be obtained by decomposing one litre of ammonia?

$$2H_3N = 3H_2 + N_2.$$

Ans. 1500 c. c. of H, 500 c. c. of N.

211. How many litres of air are necessary to burn 10 litres of marsh gas?

$$H_4C + 2O_2 = CO_2 + 2H_2O.$$

Composition of air by volume, O = 20·96
N = 79·04
100·00

Ans. 95·42 nearly.

212. After liberating by chlorine the iodine in 265 c. c. of hydroiodic acid gas, there were 318 c. c. of a mixture of hydrochloric acid and chlorine gases; what was the volume of each gas in the mixture?

$$2HI + Cl_2 = 2HCl + I_2.$$

Ans. 265 c. c. of HCl, 53 c. c. of Cl.

213. 30 litres of hydrogen were mixed with 18 litres of oxygen and chemical

union produced; how much aqueous vapor having a temperature of 140° C. and pressure of 760 m. m. was obtained? Which gas remained in excess, and what was its volume at the temperature and pressure given above?

$$2H_2 + O_2 = 2H_2O.$$

Ans. 45·3846 + of H_2O, 4·53846 + of O.

214. How many c. c. of air are necessary to burn a mixture containing 375 c. c. of marsh gas (H_4C) and 450 c. c. of olefiant gas (H_4C_2), and how much carbon dioxide and aqueous vapor are produced?

$$H_4C + 2O_2 = CO_2 + 2H_2O.$$

$$H_4C_2 + 3O_2 = 2CO_2 + 2H_2O.$$

Ans. 10219·084 c. c. nearly of air; 1275 c. c. of carbon dioxide; 1650 c. c. of aqueous vapor.

XIV.

Diffusion of Gases.

Molecular weights of gases are inversely proportional to the square of the velocity of diffusion.

The diffusive power of air being taken as unity, Graham found that the diffusive power of hydrogen is 3·83.

215. The diffusive power of a gas was found by Graham to be ·812 (air being taken as unity.) Analysis shows that in 100 parts of the gas there are 27·273 parts of carbon and 72·727 parts of oxygen. What is its molecular weight, symbol and specific gravity?

By proceeding as in problem 175, we find that for every atom of carbon there are two atoms of oxygen, and hence that the molecular weight is 44, 88, 132 or some other multiple of 44. From the law of diffusion of gases given above

$$\cdot 812^2 : 3\cdot 83^2 :: 2 : x = 44\cdot 4+,$$

which fixes 44 as the molecular weight (2 is the molecular weight of hydrogen). The symbol CO_2 and specific gravity 22, are then easily found.

216. The rate of diffusion of a gas as compared with air is found to be 1·344. On analysis, 100 parts yielded 75 parts of carbon and 25 parts of hydrogen. What

is its molecular weight, symbol and specific gravity?

Ans. Molecular weight 16; symbol H_4C; specific gravity 8.

217. The rate of diffusion of a gas is found to be 1·0149. Analysis shows that in 100 parts there are 85·714 parts of carbon and 14·286 parts of hydrogen. What is its molecular weight, specific gravity and symbol?

Ans. Molecular weight 28; specific gravity 14; symbol H_4C_2.

218. The velocity of diffusion of nitrogen is 1·0143. How many atoms of nitrogen in a molecule?

Ans. 2.

219. The velocity of diffusion of oxygen is ·9487. How many atoms of oxygen in a molecule?

Ans. 2.

220. What is the rate of diffusion of sulphurous oxide (SO_2)?

Ans. ·677+

221. What is the rate of diffusion of hydrogen arsenide (H_3As)?

Ans. ·6133 nearly.

XV.

Specific Heat.

The specific heat of a substance expresses the number of units of heat required to raise the temperature of a unit mass of the substance one degree.

A unit of heat is the quantity of heat necessary to raise the temperature of a unit mass of water one degree.

222. A kilogram of water at 10° was mixed with a kilogram of mercury at 100°, and the mixture was found to have a temperature of 12°·9. Determine the specific heat of mercury.

The amount of heat gained by the water was 2·9 units, which was furnished by the mercury causing the latter to fall through 87°·1. Hence the specific heat of mercury is $\frac{2\cdot9}{89\cdot1} = .033$.

223. A mass of matter weighing two kilograms at the temperature of 80° is mixed with five kilograms of water at 10°. The mixture was found to have

the temperature of 10°·87. What is the specific heat of the body?

The temperature of the water was raised 10°·87 − 10° = ·87°; hence the water acquired ·87° × 5 = 4·35 units of heat, which were furnished by the two kilograms of the substance, causing it to fall 80° − 10°·87 = 69°13. Hence $2(80 - 10{\cdot}87)x = 5(10{\cdot}87 - 10)$

$$x = \frac{5(10{\cdot}87 - 10)}{2(80 - 10{\cdot}87)} = {\cdot}031455,$$ the specific heat required.

For determining specific heat by the *method of mixture* as in the last two problems, the following formula will be found convenient:

$$S = \frac{W(t - T)}{W'(T' - t)} \quad [11],$$

in which W denotes the weight of water, T the temperature of the water, t the temperature of the mixture, W′ the weight of the substance, T′ the temperature of the substance, and S the specific heat required.

224. Into a calorimeter were placed 75

grams of iron having a temperature of 100°, which reduced 10·76 grams of ice to water. What is the specific heat of iron?

To melt a unit mass of ice, 79·25 units of heat are necessary; hence the iron in cooling to zero gave out $79{\cdot}25 \times 10{\cdot}76$ units of heat, and therefore

$$75 \times 100 \times x = 79{\cdot}25 \times 10{\cdot}76$$

$$x = \frac{79{\cdot}25 \times 10{\cdot}76}{76 \times 100} = {\cdot}1137,$$ the specific heat of iron.

For determining the specific heat by the *method of fusion*, as in the last problem, the following formula will be found convenient:

$$S = \frac{79{\cdot}25W}{W'T} \quad [12],$$

in which W denotes the weight of ice melted, W′ the weight of the substance, T its temperature, and S the specific heat required.

225. A mass of matter weighing 6·17 kilograms at the temperature of 80° is mixed with 25·45 kilograms of water at 12°·5. The mixture is found to have

the temperature 14°·17. What is the specific heat of the body?

Ans. ·106253.

226. Into a calorimeter were placed 100 grams of iron having a temperature of 100°, which reduced 14·35 grams of ice to water. Find the specific heat of iron.

Ans. ·1137.

227. The temperature resulting from mixing one kilogram of a substance at 20° with one kilogram of water at zero was 0·634°. Calculate the specific heat of the substance.

Ans. ·0327.

228. A mass of copper weighing 85 grams and having a temperature of 110° was placed in a calorimeter causing 11·23 grams of ice to be melted. What is the specific heat of copper?

Ans. ·09518.

229. If the same volumes of water and mercury cool through the same number of degrees in 10 minutes and 270 seconds respectively, what is the specific heat of mercury, its specific gravity being 13·6?

Ans. ·03308.

230. How many grams of ice can be melted by 100 grams of sulphur having an initial temperature of 90°? The specific heat of sulphur is ·178.

Ans. 20·2145.

231. A pound of lead at 50° is immersed in a pound of water at zero. What is the resulting temperature? The specific heat of lead is ·0314.

Ans. 1°·52.

232. A pound of cold iron is placed in a pound of water at 200° F. The water loses 5° of temperature. How much has the iron gained? Specific heat of iron is ·114.

Ans. 43°·86.

233. One kilogram of water at 40°, 2 kilograms at 30°, 3 at 20°, and 4 at 5° are mixed together. What is the temperature of the mixture?

Ans. 18°.

234. Equal volumes of mercury at 100° C. and water at zero are mixed together. What is the temperature of the mixture?

Specific heat of mercury is ·033 and its specific gravity is 13·6.

Ans. 30°·97.

235. Equal volumes of mercury at 32° F. and water at 212° are mixed together. What is the temperature of the mixture?

Ans. 155°·88.

236. A cubic metre of water yields one degree of its heat to 1000 cubic metres of air. What is the increase in the temperature of the air, if the specific heat of the water is four times and its specific gravity is 770 times that of air?

Ans. 3°·08.

237. A bar of platinum weighing 150 grams is heated in a furnace until its temperature becomes constant, when it was cooled in a kilogram of water the temperature of which it raises from 15° to 20°. Find the temperature of the furnace on supposition that the specific heat of platinum is ·03308 + ·0000042t between 0° and t°.

Ans. 893°.

238. A glass tube weighing 5·5 grams, containing 165 grams of a liquid and supported by a brass wire gauze weighing 2·5 grams, was immersed in 475 grams of water contained in a copper vessel weighing 57 grams. The temperature of the liquid, glass bulb and wire gauze was 35°. The temperature of the water and copper vessel was 13°; the temperature of the mixture was 16°. The specific heat of the glass is ·117, of the wire gauze is ·094, of the copper vessel is ·09215. Neglecting the heat lost by radiation, what was the specific heat of the liquid?

The liquid, glass tube, and wire support in falling through 35°—16° raised the temperature of the water and copper vessel through 16°—13°. Hence denoting the specific heat of the liquid by S we have

$$165S(35-16)+(5{\cdot}5\times{\cdot}117)\ (35-16)+(2{\cdot}5\times{\cdot}094)\ (35-16)=475\,(16-13)+(57\times{\cdot}09215)\ (16-13).$$

$$S=\frac{(475+57\times\cdot09125)\,(16-13)-(5\cdot5\times\cdot117+2\cdot5\times\cdot094)\,(35-16)}{165(35-16)}=\cdot4542.$$

The following general equation may be used for solving problems like the above :

$$S=\frac{(W+ws+w's'+w''s'')\,(t-T)-(mc+m'c')\,(T'-t)}{W'(T'-t)}\quad[13].$$

W = weight of water,
w = weight of the vessel containing the water,
s = specific heat of vessel containing the water,
w′ = weight of the glass of thermometer used,
s′ = specific heat of glass of thermometer used,
w″ = weight of mercury in the thermometer used,
s″ = specific heat of mercury in the thermometer used,
m = weight of vessel containing substance,
c = specific heat of vessel containing substance,

m′=weight of support of vessel containing substance,
c′=specific heat of support of vessel containing substance,
W′=weight of substance,
T=temperature of water,
T′=temperature of substance,
t=temperature of mixture,
S=specific heat required.

The number of terms in the above equation may vary. The expression of which (t—T) is a part, should represent the quantity of heat gained by the water, its containing vessel, the thermometer and stirring rod, if one is used; the rest of the numerator representing the quantity of heat given up by the envelope and supports of the substance.

239. Find the specific heat of a substance from the following data:
Weight of the substance 56 grams,
Weight of vessel containing substance 5·2 grams,
Specific heat of vessel containing substance ·197,
Weight of support of vessel 3 grams,

Specific heat of support of vessel ·114,
Weight of water in calorimeter 280 grams,
Weight of calorimeter 36 grams,
Specific heat of calorimeter ·197,
Weight of thermometer used 20 grams,
Specific heat of thermometer used ·115,
Temperature of substance and supports 100°,
Temperature of water and calorimeter 20°,
Temperature of mixture 28°.

Ans. ·5746 nearly.

240. Find the specific heat of iron from the following data:
Weight of iron 4·4 grams,
Weight of vessel and water 162 grams,
Weight of vessel 12 grams,
Specific heat of vessel ·1976,
Temperature of iron 98°,
Temperature of water 10°,
Temperature of mixture 10°·29.

Ans. ·1145 nearly.

XVI.

Latent Heat.

The latent heat of fusion (often called the latent heat the liquid) expresses the number of thermal units required to change a unit mass of the substance from solid to liquid condition. The latent heat of vaporization (often called the latent heat of the vapor) expresses the number of thermal units required to change a unit mass of the substance from liquid to gaseous condition.

Of Fusion.

241. A lump of ice at zero and weighing 2 kilograms was immersed in 5 kilograms of water having a temperature of 35°·9. After the ice was melted the temperature of the mixture was found to be 3°. What is the latent heat of water?

Let l denote the latent heat. The two kilograms of ice, by fusing and gaining a temperature of 3°, have received an

amount of heat equal to $2l+2\times3$ which was obtained from the 5 kilograms of water in falling from 35°·9 to 3°. Hence

$$2l+2\times3=5\ (35°\cdot9-3)$$

$$l=\frac{5(35°\cdot9-3)-2\times3}{2}=79\cdot25.$$

Using the same notation as in [13] so far as applicable we have

$$l=\frac{W(T-t)-W't}{W'}\quad[14].$$

242. Into 90 grams of water having a temperature of 20° were immersed 6·5 grams of sulphur at 172°·5. The temperature of the water was raised to 23°. The melting point of sulphur is 111°, its specific heat in solid form is ·202, in liquid state is ·234. Calculate its latent heat.

The amount of heat given by the sulphur to the water is its latent heat of fusion plus the heat given out in cooling from 172°·5 to the melting point (111°) plus the heat given out in cooling from the melting point to 23°. Hence

$$90(23^\circ-20^\circ)=6\cdot5l+6\cdot5\times\cdot234(172^\circ\cdot5-111^\circ)+6\cdot5\times\cdot202(111^\circ-23^\circ)$$

$$l=\frac{90(23-20)-6\cdot5\times\cdot234(172\cdot5-111)-6\cdot5\times\cdot202(111-23)}{6\cdot5}=9\cdot371.$$

For solving problems like the above we may use the general formula

$$l=\frac{W(t-T)-W's'(T'-T'')-W's(T''-t)}{W'}\ [15],$$

in which l = latent heat,

W = weight of water in calorimeter,

W' = weight of the substance,

s = specific heat of the substance in solid form,

s' = specific heat of the substance in liquid form,

T = temperature of the water,

T' = temperature of the substance,

T'' = melting point of the substance,

t = temperature of the mixture.

243. Find the latent heat of lead from the following data :

Weight of water in calorimeter 126 grams,

Weight of lead 8 grams,

Specific heat of lead in solid state ·0314,

Specific heat of lead in liquid state ·0402,

Temperature of water 16°·5,

Temperature of lead 540°,

Fusing point of lead, 326°.

Temperature of mixture 18°.

Ans. 5·3667.

244. If, after 35 kilograms of water at 59° are used to melt 8 kilograms of ice at zero, the temperature of the mixture is 33°·3, what is the latent heat of water ?

Ans. 79·1275.

245. Into a calorimeter whose equivalent in water is 260 were placed 10 grams of tin having a temperature of 460°. The temperature of the calorimeter rose from 19° to 21°·5. The melting point of tin is 232° ; its specific heat in solid state is ·056 ; in liquid condition is ·064. Calcu-

late the latent heat of fusion of the metal.

Ans. 14·245.

246. After the ice is melted, what is the temperature of a mixture of 10 kilograms of water at 100 and 3 kilograms of ice at zero?

Ans. 58°·63.

247. The temperature of 200 kilograms of water was reduced from 16° to 10° by the use of ice. How much ice was used?

Ans. 13·445.

248. The specific heat of mercury being ·0333, how much ice at its melting point is required to reduce the temperature of 10 kilograms of mercury from 100° to zero?

Ans. ·42 kilogram.

249. A mass of iron weighing 60 grams, having a temperature of 100° and a specific heat of ·114, is enclosed in a cavity of a block of ice. How much ice was melted? The latent heat of water is 79·25.

Ans. 8·631 grams, nearly.

250. The mechanical equivalent of heat is 423 kilogrammetres. From what height must a block of ice at the temperature of zero, fall that the heat generated by its collision with the earth shall be sufficient to melt it?

Ans. 33522·75 metres.

Of Vaporization.

251. In the worm of a calorimeter 6 grams of vapor of alcohol were condensed, causing the 500 grams of water in the calorimeter to rise in temperature from 12° to 15°. The boiling point of alcohol is 79° and its specific heat is ·6651; what is the latent heat of its vapor?

The heat which raised the temperature of the 500 grams of water from 12° to 15° came partly from the latent heat disengaged by the condensation of the 6 grams of alcohol vapor and partly from the loss of temperature of the condensed alcohol which fell from its boiling point to 15°. Hence denoting the latent heat l,

$$500(15-12)=6l+6\times\cdot6651(79-15)$$

$$l=\frac{500(15-12)-6\times\cdot6651(79-15}{6}=207\cdot4.$$

The following formula will be found convenient for solving problems similar to the above:

$$l=\frac{W(t-T)W's(T'-t)}{W'}$$

W = value of calorimeter in water,
W′ = weight of condensed vapor,
s = specific heat of condensed vapor,
T = initial temperature of calorimeter,
t = final temperature of calorimeter,
T′ = boiling point of the liquid,
l = latent heat of vaporization.

252. In a calorimeter containing 600 grams of water and having an initial temperature of 19° were condensed 12·6 grams of acetic acid the boiling point of which is 120°, and specific heat of which is ·6589. The final temperature of the calorimeter was 22°·5. What is the latent heat of the vapor of the acetic acid?

Ans. 102·5.

253. A calorimeter whose water value is 500 grams had its temperature raised from 12° to 18° by condensing 4·847 grams of steam. What is the latent heat of the steam?

Ans. 536·9.

254. How many kilograms of steam at 100° will be required to raise the temperature of 10 kilograms of water from zero to 90? The latent heat of steam is 537.

Ans. 1·4354.

255. How many kilograms of steam at 100° will be required to melt 100 kilograms of ice at zero? Latent heat of water is 79·25.

Ans. 12·44+

256. If one kilogram of steam at 100° be mixed with 49 kilograms of water at 15°; what will be the temperature of the mixture?

Ans. 27°·45.

257. The specific heat of alcohol is ·6215, the latent heat of its vapor is 208. Calculate the amount of vapor of alcohol which must be condensed in order to raise the temperature of 5 kilograms of alcohol from 15° to 30°.

Ans. ·1876 kilograms.

XVII.

Calorific Power.

The calorific power of a substance is measured by the number of kilograms of water which are raised one degree centigrade by the burning of one kilogram of the substance in oxygen or air.

258. If by the combustion of 3·5 grams of carbon the temperature of 14·14 kilograms of water is raised 2°, what is the calorific power of the carbon?

The number of units of heat obtained by the combustion of one kilogram of carbon will evidently be

$$14{\cdot}14 \times 2 \div (3{\cdot}5 \div 1000) = 8080.$$

259. By the combustion of 3 grams of ether the temperature of 3·009 kilograms of water is raised from 12° to 21°. What is the calorific power of ether?

Ans. 9027.

260. If the temperature of 3·592 kilograms of water is raised 4° by the combustion of 2·5 c.c. of alcohol having a specific gravity of ·8, what is the calorific power of the alcohol?

Ans. 7184.

When the combustible contains oxygen and hydrogen, the hydrogen available as fuel is that which is in excess of that required to form water with the oxygen present. The latent heat of the aqueous vapor formed, and of the hygroscopic water present, must be deducted from the calorific power of substance burnt.

261. Calculate the calorific power of coal which has the following percentage

composition: carbon 88·42, hydrogen 5·61, oxygen 5·97.

It is readily seen from its composition that one kilogram of the coal contains 884·2 grams of carbon, 56·1 grams of hydrogen and 59·7 grams of oxygen. The quantity of hydrogen combined with oxygen as water (59·7÷8) is 7·46 grams, leaving hydrogen available for fuel, 56·1—7·46=48·64 grams. The quantity of water formed by burning 56·1 grams of hydrogen (56·1 × 9) is 504·9 grams.

884·2 grams of carbon* yield.....7144·336 units of heat,
48·64 grams of hydrogen yield....1676·232 units of heat,

Total.....8820·568 units of heat.

Heat latent in 504·9 grams of water (·5049 × 606·5), is..... 306·222 units of heat,

Calorific power of the coal.....8514·346 units.

* For calorific power of substances mentioned in this and other problems see Table VI.

262. Calculate the calorific power of dried peat from the following percentage composition: carbon 62·54, hydrogen 6·81, oxygen 29·24, nitrogen 1·41 (nitrogen and other non-combustibles do not affect the calorific power).

Ans. 5768·78.

263. Calculate the calorific power of wood having the following percentage composition: carbon 40, hydrogen 4·8, oxygen 32·8, hydroscopic water 20, ashes 2·4.

Ans. 3090 nearly.

264. How many kilograms of water can be heated one degree centigrade by the burning of five grams of hydrogen?

Ans. 172·31.

265. How many grams of phosphorus are required to heat one kilogram of water from zero to boiling point?

Ans. 17·428.

266. How much water can be heated from zero to 20° by the combustion of three grams of sulphur?

Ans. 333·1 grams.

267. How many litres of hydrogen are

required to raise the temperature of three kilograms of water from zero to boiling point?

Ans. 97·157 litres.

268. The mechanical equivalent of heat being 423 kilogrammetres, what mechanical power is developed by the combustion of one kilogram of charcoal?

Ans. 3417840 kilogrammetres.

XVIII.

Calorific Intensity.

Calorific intensity is the maximum temperature developed in the process of combustion. It is found by dividing the calorific power by the sum of the products arising from multiplying the relative weights of the substances produced, by their specific heats.

269. From the following data, find the calorific intensity of marsh gas (H_4C) burnt in oxygen.

$$H_4C + 2O_2 = CO_2 + 2H_2O.$$

Calorific power of marsh gas is 13063. Specific heat of carbon dioxide (CO_2) is ·2164. Specific heat of steam (H_2O) is ·4805.

From the equation it is easily found that one kilogram of marsh gas produces by combustion 2·75 kilograms of CO_2 and 2·25 kilograms of H_2O.

Calorific intensity of marsh gas=

$$\frac{13063}{2\cdot75\times\cdot2164+2\cdot25\times\cdot4805}=7793°.1,\ \textit{Ans.}$$

270. What is the calorific intensity of marsh gas burnt in air? Specific heat of nitrogen is ·244. Equation and other data is in the preceding problem. When burnt in air the inert nitrogen of the air must be regarded as one of the products. From the equation it is found that one kilogram of H_4C consumes, in burning, 4 kilograms of oxygen. Air is composed of oxygen 23·2 parts to nitrogen 76·8 parts.

23·2 : 76·8 :: 4 : 13·24=the nitrogen.

Ans. 2662°·2.

271. What is the calorific intensity of

olefiant gas (H_4C_2) when burnt in oxygen? When burnt in air?

$$H_4C_2 + 3O_2 = 2CO_2 + 2H_2O.$$

Calorific power of H_4C_2 is 11858. Specific heat of CO_2, H_2O and nitrogen as in the two preceding problems.

Ans. Burnt in oxygen 9136·3; in air 2915·4.

272. What is the calorific intensity of charcoal when burnt in oxygen? When burnt in air?

$$C + O_2 = CO_2.$$

Calorific power of carbon is 8080. Specific heat of CO_2 and nitrogen same as above.

Ans. Burnt in oxygen 10173·9; in air 2737·9.

273. Calculate the calorific intensity of hydrogen burnt in oxygen and in air.

$$2H_2 + O_2 = 2H_2O.$$

Specific heat of H_2O and nitrogen as above.

When hydrogen is burnt under ordinary conditions the aqueous vapor is not condensed, and hence its calorific power is less than that given in the table. One

part hydrogen yields nine parts vapor. The latent heat of the vapor at zero is 606·5; hence the calorific power of hydrogen burnt under ordinary conditions is $34462-(606{\cdot}5\times 9)=29003{\cdot}5$.

Ans. Burnt oxygen 6706·87; in air 2688·47.

XIX.

APPENDIX.

TABLE I.

METRIC MEASURES AND WEIGHTS.

LINEAR MEASURE.

Divisions.....	MILLIMETRE	=	0·001 or 1-1,000 of a metre.
	CENTIMETRE	=	0·01 or 1-100 "
	Decimetre	=	0·1 or 1-10 "
Unit.....	METRE	=	1·
Multiples.....	Decametre	=	10·
	Hectometre	=	100·
	KILOMETRE	=	1,000·

Surface Measure.

Divisions.....	Millimetre square	=	0·000,001 of a metre square.
	Centimetre square	=	0·000,1 " "
	Decimetre square	=	0·01 " "
Unit.....	Metre Square	=	1· " "

Cubic Measure.

			Cubic Metre.
Divisions.....	Cubic Millimetre	=	0·000,000,001
	Cubic Centimetre	=	0·000,001
	Cubic Decimetre	=	0 001
Unit.....	Cubic Metre	=	1·
Multiples.....	Cubic Decametre	=	1,000·
	Cubic Hectometre	=	1,000,000·
	Cubic Kilometre	=	1,000,000,000·

Capacity Measure.

		Litres.	Cubic Metre.	
Divisions	Millilitre	= 0·001	= 0·000,001	= 1 cubic centimetre.
	Centilitre	= 0·01	= 0·000,01	
	Decilitre	= 0·1	= 0·000,1	
Unit	Litre	= 1·	= 0·001	= 1 cubic decimetre.
Multiples	Decalitre	= 10·	= 0·01	
	Hectolitre	= 100·	= 0·1	
	Kilolitre	= 1,000·	= 1·	= 1 cubic metre.

Weights.

		Grams.	
Divisions	Milligram	= 0·001	
	Centigram	= 0·01	
	Decigram	= 0·1	
Unit	Gram	= 1·=1	cubic centimetre of water at 4°
Multiples	Decagram	= 10·	
	Hectogram	= 100·	
	Kilogram	= 1,000·=1	cubic decimetre of water at 4°.

ABBREVIATIONS.

m., metre,	c. c., cubic centimetre.
c. m., centimetre,	grm., gram.
m. m., millimetre,	kilo., kilogram.

TABLE II.

CONVERSION OF METRIC INTO ENGLISH MEASURES.

MEASURES OF LENGTH.

1 Millimetre	=	·03937079 inch, or about $\frac{1}{25}$ inch.
1 Centimetre	=	·3937079 inch.
1 Decimetre	=	3·937079 inches.
1 Metre	=	39·37079 inches, or 3·2809 feet nearly.
1 Kilometre	=	39370·79 inches, or ·6214 mile.

Measures of Area.

1 sq. millimetre	=	·00155006 sq. inch.
1 sq. centimetre	=	·155006 sq. inch.
1 sq. decimetre	=	15·5006 sq. inches.
1 sq. metre	=	1550·06 sq. inches, or 10·7643 sq. feet.

Measures of Volume.

1 cubic centimetre	=	·0610271 cubic inch.
1 cubic decimetre	=	61·0271 cubic inches.
1 cubic metre	=	61027·1 cubic inches, or 35·3166 cubic feet.

The litre (used for liquids) is the same as the cubic decimetre, and is equal to 1·76172 imperial pint, or ·220215 gallon, or 1·05708 U. S. quart.

Measures of Weight (or Mass.)

1 milligram	=	·015432349 grain.
1 centigram	=	·15432349 grain.
1 decigram	=	1·5432349 grain.
1 gram	=	15·432349 grains.
1 kilogram	=	15432·349 grains, or 2·20462125 lbs. avoir.

MEASURES INVOLVING REFERENCE TO TWO UNITS.

1 gram per sq. centimetre	=	2·048098 lbs per sq. foot.
1 kilogram per sq. metre	=	·2048098 " "
1 kilogram per sq. millimetre	=	204809·8 " "
1 kilogrammetre	=	7·23314 foot-pounds.

1 force de cheval = 75 kilogrammetres per second, or 542½ foot-pounds per second nearly, whereas 1 horse-power (English)=550 foot-pounds per second

To reduce grams to grains.

Log. grams+1·188432=log. grains.

To reduce cubic centimetres to cubic inches.

Log. c. c.+(−2·7855007)=log. cubic inches.

To reduce millimetres to inches.

og. m. m.+(−2·5951663)=log. inches.

TABLE III.

CONVERSION OF ENGLISH INTO METRIC MEASURES.

Measures of Length.

1 inch=25·39954 millimetres.
1 foot = ·30479449 metre.
1 yard= ·91438347 metre.
1 mile= 1·60932 kilometre

Measures of Area.

1 sq. inch=615·137 sq. millimetres.
1 sq. foot = ·0928997 sq. metre.
1 sq. yard= ·8360973 sq. metre.
1 sq. mile= 2·589895 sq. kilometres.

Solid Measures.

1 cubic inch=16386·6 cubic millimetres
1 cubic foot= ·0283153 cubic metre.
1 cubic yard= ·7645131 cubic metre.

Measures of Capacity.

1 pint = ·5676275 litre.
1 gallon = 4·54102 litres.
1 bushel=36·32816 litres.

Measures of Weight.

1 grain = ·064799 gram.
1 oz. avoir. = 28·3496 grams.
1 lb. avoir. = ·453593 kilogram.
1 ton = 1·01605 tonne = 1016·05 kilos.

Measures involving reference to two units.

1 lb. per sq. foot = 4·88261 kilos. per sq. metre.
1 lb. per sq. inch = ·0703095 kilos. per sq. centimetre.
1 foot-pound = ·138253 kilogrammetre

To convert grains into grams.

Log. grains + (−2·8115680) = log. grams.

To convert cubic inches into cubic centimetres.

Log. cb. in. + 1·2144993 = log. c. c.

To convert inches into millimetres.

Log. inches + 1·4048337 = log. m. m.

TABLE IV.

ELEMENTARY ATOMS.

ALPHABETICAL LIST.

Aluminum	Al	27·0
Antimony	Sb	120·0
Arsenic	As	75·
Barium	Ba	137·1
Bismuth	Bi	210·0
Boron	B	11·0
Bromine	Br	80·0
Cadmium	Cd	112·3
Cæsium	Cs	133·
Calcium	Ca	40·0
Carbon	C	12·0
Cerium	Ce	141·0
Chlorine	Cl	35·5
Chromium	Cr	52·2
Cobalt	Co	58·8
Columbium	Cb	94·
Copper	Cu	63·4
Decipium (?)	Dp	159·
Didymium	D	140·
Erbium	Er	167·

ELEMENTARY ATOMS—Continued.

Fluorine	F	19·0
Gallium	Ga	70·0
Glucinum	Gl	13·9
Gold	Au	197·
Holmium (?)	Ho	162·?
Hydrogen	H	1·00
Indium	In	113·7
Iodine	I	126·8
Iridium	Ir	192·7
Iron	Fe	56·0
Lanthanum	La	139·
Lead	Pb	206·9
Lithium	Li	7·0
Magnesium	Mg	24·0
Manganese	Mn	55·0
Mercury	Hg	200·0
Molybdenum	Mo	96·
Nickel	Ni	58·8
Nitrogen	N	14·0
Norwegium (?)	Ng	145·9?
Osmium	Os	199·2
Oxygen	O	16·0
Palladium	Pa	106·6
Phosphorus	P	31·0
Platinum	Pt	194·8
Potassium	K	39·1

ELEMENTARY ATOMS—Concluded.

Rhodium	Rh	104·4
Rubidium	Rb	85·4
Ruthenium	Ru	104·4
Scandium	Sc	44·
Selenium	Se	79·2
Silicon	Si	28·
Silver	Ag	108·0
Sodium	Na	23·0
Strontium	Sr	87·6
Sulphur	S	32·0
Tantalum	Ta	182·
Tellurium	Te	128·
Terbium (?)	Tr	171·?
Thallium	Tl	204·1
Thorium	Th	231·4
Thulium (?)	Tm	170·?
Tin	Sn	118·
Titanium	Ti	50·0
Tungsten	Wo	184·
Uranium	Ur	120·
Vanadium	V	51·3
Ytterbium (?)	Yb	173·?
Yttrium	Y	91·?
Zinc	Zn	65·2
Zirconium	Zr	89·6

TABLE V.

SPECIFIC HEAT OF ELEMENTARY SUBSTANCES.

The specific heat of boron was determined at 233°, cadmium at 37°, carbon (diamond) at 985°, mercury at −59°, phosphorus at 19°, potassium at −34°, silicon at 232°·4, sodium at −14°. The specific heats of the other elements were determined at temperatures between 50° and 67°. Crystallized varieties of arsenic, boron, selenium and silicon were used.

Names.	Specific Heat.	Atomic Weight.	Product.
Aluminum.....	0·214	27	5·8
Antimony.....	0·0508	120	6·1
Arsenic.....	0·0814	75	6·1
Bismuth.....	0·0308	210	6·5
Boron.....	0·391	11	4·3
Cadmium.....	0·0542	112	6·1
Calcium.....	0·170	40	6·8
Carbon.....	0·459	12	5·5
Cerium.....	0·0448	141	6·3
Cobalt.....	0·107	59	6·3
Copper.....	0·0952	63	6·0
Didymium.....	0·0456	140	6·4
Glucinum.....	0·408	13·9	5·6
Gold.....	0·0324	197	6·4
Indium.....	0·0570	113.7	6·5

SPECIFIC HEAT OF ELEM. SUB.—Concluded.

Names.	Specific Heat.	Atomic Weight.	Product.
Iodine	0·0541	127	6·9
Iridium	0·0326	192·7	6·4
Iron	0·114	56	6·4
Lanthanum	0·0449	139	6·2
Lead	0·0314	207	6·5
Lithium	0·941	7	6·6
Magnesium	0·250	24	6·0
Mercury	0·0319	200	6·4
Nickel	0·108	59	6·4
Osmium	0·0311	199	6·2
Palladium	0·0593	106·6	6·3
Phosphorus	0·189	31	5·9
Platinum	0·0324	194·8	6·3
Potassium	0·166	39·1	6·5
Rhodium	0·0580	104·4	6·0
Ruthenium	0·0611	104·4	6·3
Selenium	0·0762	79·2	6·1
Silicon	0·2029	28	5·7
Silver	0·0570	108	6·1
Sodium	0·2930	23	6·7
Sulphur	0·178	32	5·7
Tellurium	0·0474	128	6·1
Thallium	0·0335	204	6·8
Tin	0·0562	118	6·6
Tungsten	0·0334	184	6·1
Zinc	0·0955	65	6·2

TABLE VI.

CALORIFIC POWER.

Hydrogen	34462
Carbon	8080
Phosphorus	5747
Sulphur	2221
Iron	1576
Zinc	1301
Tin	1144
Copper	602
Carbon Monoxide	2400
Marsh Gas	13063
Olefiant Gas	11858
Ether	9027
Alcohol	7184
Cobalt	1080
Nickel	1006
Antimony	961
Cyanogen	5195
Olive oil	9862
Oil of turpentine	10852
Carbon disulphide	3401

LOGARITHMS OF NUMBERS.

COMMON LOGARITHMS TO FOUR FIGURES.

N.	Log.	N.	Log.	N.	Log.	N.	Log.
		25	.3979	50	.6990	75	.8751
1	.0000	26	.4150	51	.7076	76	.8808
2	.3010	27	.4314	52	.7160	77	.8865
3	.4771	28	.4472	53	.7243	78	.8921
4	.6021	29	.4624	54	.7324	79	.8976
5	.6990	30	.4771	55	.7404	80	.9031
6	.7782	31	.4914	56	.7482	81	.9085
7	.8451	32	.5051	57	.7559	82	.9138
8	.9031	33	.5185	58	.7634	83	.9191
9	.9542	34	.5315	59	.7709	84	.9243
10	.0000	35	.5441	60	.7782	85	.9294
11	.0414	36	.5563	61	.7853	86	.9345
12	.0792	37	.5682	62	.7924	87	.9395
13	.1139	38	.5798	63	.7993	88	.9445
14	.1461	39	.5911	64	.8062	89	.9494
15	.1761	40	.6021	65	.8129	90	.9542
16	.2041	41	.6128	66	.8195	91	.9590
17	.2304	42	.6232	67	.8261	92	.9638
18	.2553	43	.6335	68	.8325	93	.9685
19	.2788	44	.6435	69	.8388	94	.9731
20	.3010	45	.6532	70	.8451	95	.9777
21	.3222	46	.6628	71	.8513	96	.9823
22	.3424	47	.6721	72	.8573	97	.9868
23	.3617	48	.6812	73	.8633	98	.9912
24	.3802	49	.6902	74	.8692	99	.9956

N.	0	1	2	3	4	5	6	7	8	9
100	.00 00	04	09	13	17	22	26	30	35	39
101	.00 43	48	52	56	60	65	69	73	77	82
102	.00 86	90	95	99	*03	*07	*11	*16	*20	*24
103	.01 28	33	37	41	45	49	54	58	62	66
104	.01 70	75	79	83	87	91	95	99	*04	*08
105	.02 12	16	20	24	28	33	37	41	45	49
106	.02 53	57	61	65	69	73	78	82	86	90
107	.02 94	98	*02	*06	*10	*14	*18	*22	*26	*30
108	.03 34	38	42	46	50	54	58	62	66	70
109	.03 74	78	82	86	90	94	98	*02	*06	*10
110	.04 14	18	22	26	30	34	38	41	45	49
111	.04 53	57	61	65	69	73	77	81	84	88
112	.04 92	96	*00	*04	*08	*12	*15	*19	*23	*27
113	.05 31	35	38	42	46	50	54	58	61	65
114	.05 69	73	77	80	84	88	92	96	99	*03
115	.06 07	11	15	18	22	26	30	33	37	41
116	.06 45	48	52	56	60	63	67	71	74	78
117	.06 82	86	89	93	97	*00	*04	*08	*11	*15
118	.07 19	22	26	30	34	37	41	45	48	52
119	.07 55	59	63	66	70	74	77	81	85	88
120	.07 92	95	99	*03	*06	*10	*13	*17	*21	*24
121	.08 28	31	35	39	42	46	49	53	56	60
122	.08 64	67	71	74	78	81	85	88	92	96
123	.08 99	*03	*06	*10	*13	*17	*20	*24	*27	*31
124	.09 34	38	41	45	48	52	55	59	62	66
125	.09 69	73	76	80	83	86	90	93	97	*00
126	.10 04	07	11	14	17	21	24	28	31	35
127	.10 38	41	45	48	52	55	59	62	65	69
128	.10 72	75	79	82	86	89	92	96	99	*03
129	.11 06	09	13	16	19	23	26	29	33	36

N.	0	1	2	3	4	5	6	7	8	9
130	.11 39	43	46	49	53	56	59	63	66	69
131	.11 73	76	79	83	86	89	93	96	99	*02
132	.12 06	09	12	16	19	22	25	29	32	35
133	.12 39	42	45	48	52	55	58	61	65	68
134	.12 71	74	78	81	84	87	90	94	97	*00
135	.13 03	07	10	13	16	19	23	26	29	32
136	.13 35	39	42	45	48	51	55	58	61	64
137	.13 67	70	74	77	80	83	86	89	92	96
138	.13 99	*02	*05	*08	*11	*14	*18	*21	*24	*27
139	.14 30	33	36	40	43	46	49	52	55	58
140	.14 61	64	67	71	74	77	80	83	86	89
141	.14 92	95	98	*01	*04	*08	*11	*14	*17	*20
142	.15 23	26	29	32	35	38	41	44	47	50
143	.15 53	56	59	62	65	69	72	75	78	81
144	.15 84	87	90	93	96	99	*02	*05	*08	*11
145	.16 14	17	20	23	26	29	32	35	38	41
146	.16 44	47	49	52	55	58	61	64	67	70
147	.16 73	76	79	82	85	88	91	94	97	*00
148	.17 03	06	08	11	14	17	20	23	26	29
149	.17 32	35	38	41	44	46	49	52	55	58
150	.17 61	64	67	70	72	75	78	81	84	87
151	.17 90	93	96	98	*01	*04	*07	*10	*13	*16
152	.18 18	21	24	27	30	33	36	38	41	44
153	.18 47	50	53	55	58	61	64	67	70	72
154	.18 75	78	81	84	86	89	92	95	98	*01
155	.19 03	06	09	12	15	17	20	23	26	28
156	.19 31	34	37	40	42	45	48	51	53	56
157	.19 59	62	65	67	70	73	76	78	81	84
158	.19 87	89	92	95	98	*00	*03	*06	*09	*11
159	.20 14	17	19	22	25	28	30	33	36	38

N.	0	1	2	3	4	5	6	7	8	9
160	.20 41	44	47	49	52	55	57	60	63	66
161	.20 68	71	74	76	79	82	84	87	90	92
162	.20 95	98	*01	*03	*06	*09	*11	*14	*17	*19
163	.21 22	25	27	30	33	35	38	40	43	46
164	.21 48	51	54	56	59	62	64	67	70	72
165	.21 75	77	80	83	85	88	91	93	96	98
166	.22 01	04	06	09	12	14	17	19	22	25
167	.22 27	30	32	35	38	40	43	45	48	51
168	.22 53	56	58	61	63	66	69	71	74	76
169	.22 79	81	84	87	89	92	94	97	99	*02
170	.23 04	07	10	12	15	17	20	22	25	27
171	.23 30	33	35	38	40	43	45	48	50	53
172	.23 55	58	60	63	65	68	70	73	75	78
173	.23 80	83	85	88	90	93	95	98	*00	*03
174	.24 05	08	10	13	15	18	20	23	25	28
175	.24 30	33	35	38	40	43	45	48	50	53
176	.24 55	58	60	63	65	67	70	72	75	77
177	.24 80	82	85	87	90	92	94	97	99	*02
178	.25 04	07	09	12	14	16	19	21	24	26
179	.25 29	31	33	36	38	41	43	45	48	50
180	.25 53	55	58	60	62	65	67	70	72	74
181	.25 77	79	82	84	86	89	91	94	96	98
182	.26 01	03	05	08	10	13	15	17	20	22
183	.26 25	27	29	32	34	36	39	41	43	46
184	.26 48	51	53	55	58	60	62	65	67	69
185	.26 72	74	76	79	81	83	86	88	90	93
186	.26 95	97	*00	*02	*04	*07	*09	*11	*14	*16
187	.27 18	21	23	25	28	30	32	35	37	39
188	.27 42	44	46	49	51	53	55	58	60	62
189	.27 65	67	69	72	74	76	78	81	83	85

N.	0	1	2	3	4	5	6	7	8	9
190	.27 88	90	92	94	97	99	*01	*04	*06	*08
191	.28 10	13	15	17	19	22	24	26	28	31
192	.28 33	35	38	40	42	44	47	49	51	53
193	.28 56	58	60	62	65	67	69	71	74	76
194	.28 78	80	82	85	87	89	91	94	96	98
195	.29 00	03	05	07	09	11	14	16	18	20
196	.29 23	25	27	29	31	34	36	38	40	42
197	.29 45	47	49	51	53	56	58	60	62	64
198	.29 67	69	71	73	75	78	80	82	84	86
199	.29 89	91	93	95	97	99	*02	*04	*06	*08
200	.30 10	12	15	17	19	21	23	25	28	30
201	.30 32	34	36	38	41	43	45	47	49	51
202	.30 54	56	58	60	62	64	66	69	71	73
203	.30 75	77	79	81	84	86	88	90	92	94
204	.30 96	98	*01	*03	*05	*07	*09	*11	*13	*15
205	.31 18	20	22	24	26	28	30	32	34	37
206	.31 39	41	43	45	47	49	51	53	56	58
207	.31 60	62	64	66	68	70	72	74	76	79
208	.31 81	83	85	87	89	91	93	95	97	99
209	.32 01	04	06	08	10	12	14	16	18	20
210	.32 22	24	26	28	30	33	35	37	39	41
211	.32 43	45	47	49	51	53	55	57	59	61
212	.32 63	65	67	69	72	74	76	78	80	82
213	.32 84	86	88	90	92	94	96	98	*00	*02
214	.33 04	06	08	10	12	14	16	18	20	22
215	.33 24	26	28	30	32	34	36	39	41	43
216	.33 45	47	49	51	53	55	57	59	61	63
217	.33 65	67	69	71	73	75	77	79	81	83
218	.33 85	87	89	91	93	95	97	98	*00	*02
219	.34 04	06	08	10	12	14	16	18	20	22

N.	0	1	2	3	4	5	6	7	8	9
220	.34 24	26	28	30	32	34	36	38	40	42
221	.34 44	46	48	50	52	54	56	58	60	62
222	.34 64	65	67	69	71	73	75	77	79	81
223	.34 83	85	87	89	91	93	95	97	99	*01
224	.35 02	04	06	08	10	12	14	16	18	20
225	.35 22	24	26	28	30	31	33	35	37	39
226	.35 41	43	45	47	49	51	53	55	56	58
227	.35 60	62	64	66	68	70	72	74	76	77
228	.35 79	81	83	85	87	89	91	93	95	96
229	.35 98	*00	*02	*04	*06	*08	*10	*12	*14	*15
230	.36 17	19	21	23	25	27	29	30	32	34
231	.36 36	38	40	42	44	46	47	49	51	53
232	.36 55	57	59	60	62	64	66	68	70	72
233	.36 74	75	77	79	81	83	85	87	88	90
234	.36 92	94	96	98	*00	*01	*03	*05	*07	*09
235	.37 11	13	14	16	18	20	22	24	25	27
236	.37 29	31	33	35	36	38	40	42	44	46
237	.37 47	49	51	53	55	57	58	60	62	64
238	.37 66	68	69	71	73	75	77	79	80	82
239	.37 84	86	88	89	91	93	95	97	98	*00
240	.38 02	04	06	08	09	11	13	15	17	18
241	.38 20	22	24	26	27	29	31	33	35	36
242	.38 38	40	42	44	45	47	49	51	52	54
243	.38 56	58	60	61	63	65	67	69	70	72
244	.38 74	76	77	79	81	83	85	86	88	90
245	.38 92	93	95	97	99	*01	*02	*04	*06	*08
246	.39 09	11	13	15	16	18	20	22	23	25
247	.39 27	29	30	32	34	36	38	39	41	43
248	.39 45	46	48	50	52	53	55	57	59	60
249	.39 62	64	65	67	69	71	72	74	76	78

N.	0	1	2	3	4	5	6	7	8	9
250	.39 79	81	83	85	86	88	90	92	93	95
251	.39 97	98	*00	*02	*04	*05	*07	*09	*11	*12
252	.40 14	16	17	19	21	23	24	26	28	29
253	.40 31	33	35	36	38	40	41	43	45	47
254	.40 48	50	52	53	55	57	59	60	62	64
255	.40 65	67	69	71	72	74	76	77	79	81
256	.40 82	84	86	87	89	91	93	94	96	98
257	.40 99	*01	*03	*04	*06	*08	*09	*11	*13	*15
258	.41 16	18	20	21	23	25	26	23	30	31
259	.41 33	35	36	38	40	41	43	45	46	48
260	.41 50	51	53	55	56	58	60	61	63	65
261	.41 66	63	70	71	73	75	76	78	80	81
262	.41 83	85	86	88	90	91	93	95	96	98
263	.42 00	01	03	05	06	08	09	11	13	14
264	.42 16	18	19	21	23	24	26	28	29	31
265	.42 32	34	36	37	39	41	42	44	46	47
266	.42 49	50	52	54	55	57	59	60	62	63
267	.42 65	67	68	70	72	73	75	76	78	80
268	.42 81	83	85	86	88	89	91	93	94	96
269	.42 98	99	*01	*02	*04	*06	*07	*09	*10	*12
270	.43 14	15	17	18	20	22	23	25	26	28
271	.43 30	31	33	35	36	38	39	41	42	44
272	.43 46	47	49	50	52	54	55	57	58	60
273	.43 62	63	65	66	68	70	71	73	74	76
274	.43 78	79	81	82	84	85	87	89	90	92
275	.43 93	95	96	98	*00	*01	*03	*04	*06	*08
276	.44 09	11	12	14	15	17	19	20	22	23
277	.44 25	26	28	29	31	33	34	36	37	39
278	.44 40	42	44	45	47	48	50	51	53	54
279	.44 56	58	59	61	62	64	65	67	68	70

N.	0	1	2	3	4	5	6	7	8	9
280	.44 72	73	75	76	78	79	81	82	84	86
281	.44 87	89	90	92	93	95	96	98	99	*01
282	.45 02	04	06	07	09	10	12	13	15	16
283	.45 18	19	21	22	24	26	27	29	30	32
284	.45 33	35	36	38	39	41	42	44	45	47
285	.45 48	50	51	53	55	56	58	59	61	62
286	.45 64	65	67	68	70	71	73	74	76	77
287	.45 79	80	82	83	85	86	88	89	91	92
288	.45 94	95	97	98	*00	*01	*03	*04	*06	*07
289	.46 09	10	12	13	15	16	18	19	21	22
290	.46 24	25	27	28	30	31	33	34	36	37
291	.46 39	40	42	43	45	46	48	49	51	52
292	.46 54	55	57	58	60	61	63	64	66	67
293	.46 69	70	72	73	75	76	78	79	81	82
294	.46 83	85	86	88	89	91	92	94	95	97
295	.46 98	*00	*01	*03	*04	*06	*07	*09	*10	*11
296	.47 13	14	16	17	19	20	22	23	25	26
297	.47 28	29	30	32	33	35	36	38	39	41
298	.47 42	44	45	47	48	49	51	52	54	55
299	.47 57	58	60	61	63	64	65	67	68	70
300	.47 71	73	74	76	77	78	80	81	83	84
301	.47 86	87	89	90	91	93	94	96	97	99
302	.48 00	02	03	04	06	07	09	10	12	13
303	.48 14	16	17	19	20	22	23	24	26	27
304	.48 29	30	32	33	34	36	37	39	40	42
305	.48 43	44	46	47	49	50	52	53	54	56
306	.48 57	59	60	61	63	64	66	67	69	70
307	.48 71	73	74	76	77	78	80	81	83	84
308	.48 86	87	88	90	91	93	94	95	97	98
309	.49 00	01	02	04	05	07	08	09	11	12

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310	.49 14	15	16	18	19	21	22	23	25	26
311	.49 28	29	30	32	33	35	36	37	39	40
312	.49 42	43	44	46	47	49	50	51	53	54
313	.49 55	57	58	60	61	62	64	65	67	68
314	.49 69	71	72	73	75	76	78	79	80	82
315	.49 83	84	86	87	89	90	91	93	94	95
316	.49 97	98	*00	*01	*02	*04	*05	*06	*08	*09
317	.50 11	12	13	15	16	17	19	20	22	23
318	.50 24	26	27	28	30	31	32	34	35	37
319	.50 38	39	41	42	43	45	46	47	49	50
320	.50 51	53	54	56	57	58	60	61	62	64
321	.50 65	66	68	69	70	72	73	75	76	77
322	.50 79	80	81	83	84	85	87	88	89	91
323	.50 92	93	95	96	97	99	*00	*01	*03	*04
324	.51 05	07	08	09	11	12	13	15	16	17
325	.51 19	20	22	23	24	26	27	28	30	31
326	.51 32	34	35	36	38	39	40	41	43	44
327	.51 45	47	48	49	51	52	53	55	56	57
328	.51 59	60	61	63	64	65	67	68	69	71
329	.51 72	73	75	76	77	79	80	81	83	84
330	.51 85	86	88	89	90	92	93	94	96	97
331	.51 98	*00	*01	*02	*04	*05	*06	*07	*09	*10
332	.52 11	13	14	15	17	18	19	21	22	23
333	.52 24	26	27	28	30	31	32	34	35	36
334	.52 37	39	40	41	43	44	45	47	48	49
335	.52 50	52	53	54	56	57	58	60	61	62
336	.52 63	65	66	67	69	70	71	72	74	75
337	.52 76	78	79	80	81	83	84	85	87	88
338	.52 89	90	92	93	94	96	97	98	99	*01
339	.53 02	03	05	06	07	08	10	11	12	14

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340	·53 15	16	17	19	20	21	22	24	25	26
341	·53 28	29	30	31	33	34	35	36	38	39
342	·53 40	42	43	44	45	47	48	49	50	52
343	·53 53	54	55	57	58	59	61	62	63	64
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345	·53 78	79	81	82	83	84	86	87	88	90
346	·53 91	92	93	95	96	97	98	*00	*01	*02
347	·54 03	05	06	07	08	10	11	12	13	15
348	·54 16	17	18	20	21	22	23	25	26	27
349	·54 28	29	31	32	33	34	36	37	38	39
350	·54 41	42	43	44	46	47	48	49	51	52
351	·54 53	54	56	57	58	59	60	62	63	64
352	·54 65	67	68	69	70	72	73	74	75	77
353	·54 78	79	80	81	83	84	85	86	88	89
354	·54 90	91	92	94	95	96	97	99	*00	*01
355	·55 02	04	05	06	07	08	10	11	12	13
356	·55 14	16	17	18	19	21	22	23	24	25
357	·55 27	28	29	30	32	33	34	35	36	38
358	·55 39	40	41	42	44	45	46	47	49	50
359	·55 51	52	53	55	56	57	58	59	61	62
360	·55 63	64	65	67	68	69	70	71	73	74
361	·55 75	76	77	79	80	81	82	83	85	86
362	·55 87	88	89	91	92	93	94	95	97	98
363	·55 99	*00	*01	*03	*04	*05	*06	*07	*09	*10
364	·56 11	12	13	15	16	17	18	19	21	22
365	·56 23	24	25	26	28	29	30	31	32	34
366	·56 35	36	37	38	40	41	42	43	44	45
367	·56 47	48	49	50	51	53	54	55	56	57
368	·56 58	60	61	62	63	64	66	67	68	69
369	·56 70	71	73	74	75	76	77	78	80	81

N.	0	1	2	3	4	5	6	7	8	9
370	.56 82	83	84	86	87	88	89	90	91	93
371	.56 94	95	96	97	98	*00	*01	*02	*03	*04
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373	.57 17	18	19	21	22	23	24	25	26	28
374	.57 29	30	31	32	33	35	36	37	38	39
375	.57 40	41	43	44	45	46	47	48	50	51
376	.57 52	53	54	55	56	58	59	60	61	62
377	.57 63	65	66	67	68	69	70	71	73	74
378	.57 75	76	77	78	80	81	82	83	84	85
379	.57 86	88	89	90	91	92	93	94	96	97
380	.57 98	99	*00	*01	*02	*04	*05	*06	*07	*08
381	.58 09	10	12	13	14	15	16	17	18	19
382	.58 21	22	23	24	25	26	27	29	30	31
383	.58 32	33	34	35	37	38	39	40	41	42
384	.58 43	44	46	47	48	49	50	51	52	53
385	.58 55	56	57	58	59	60	61	62	64	65
386	.58 66	67	63	69	70	71	73	74	75	76
387	.58 77	78	79	80	82	83	84	85	86	87
388	.58 88	89	91	92	93	94	95	96	97	98
389	.58 99	*01	*02	*03	*04	*05	*06	*07	*08	*10
390	.59 11	12	13	14	15	16	17	18	20	21
391	.59 22	23	24	25	26	27	28	30	31	32
392	.59 33	34	35	36	37	38	40	41	42	43
393	.59 44	45	46	47	48	49	51	52	53	54
394	.59 55	56	57	58	59	60	62	63	64	65
395	.59 66	67	68	69	70	71	73	74	75	76
396	.59 77	78	79	80	81	82	84	85	86	87
397	.59 88	89	90	91	92	93	94	96	97	98
398	.59 99	*00	*01	*02	*03	*04	*05	*06	*08	*09
399	.60 10	11	12	13	14	15	16	17	18	20

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400	.60 21	22	23	24	25	26	27	28	29	30
401	.60 31	33	34	35	36	37	38	39	40	41
402	.60 42	43	44	46	47	48	49	50	51	52
403	.60 53	54	55	56	57	58	60	61	62	63
404	.60 64	65	66	67	68	69	70	71	72	73
405	.60 75	76	77	78	79	80	81	82	83	84
406	.60 85	86	87	88	90	91	92	93	94	95
407	.60 96	97	98	99	*00	*01	*02	*03	*04	*06
408	.61 07	08	09	10	11	12	13	14	15	16
409	.61 17	18	19	20	21	23	24	25	26	27
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411	.61 38	39	41	42	43	44	45	46	47	48
412	.61 49	50	51	52	53	54	55	56	57	58
413	.61 60	61	62	63	64	65	66	67	68	69
414	.61 70	71	72	73	74	75	76	77	78	79
415	.61 80	82	83	84	85	86	87	88	89	90
416	.61 91	92	93	94	95	96	97	98	99	*00
417	.62 01	02	03	04	06	07	08	09	10	11
418	.62 12	13	14	15	16	17	18	19	20	21
419	.62 22	23	24	25	26	27	28	29	30	31
420	.62 32	34	35	36	37	38	39	40	41	42
421	.62 43	44	45	46	47	48	49	50	51	52
422	.62 53	54	55	56	57	58	59	60	61	62
423	.62 63	64	65	66	68	69	70	71	72	73
424	.62 74	75	76	77	78	79	80	81	82	83
425	.62 84	85	86	87	88	89	90	91	92	93
426	.62 94	95	96	97	98	99	*00	*01	*02	*03
427	.63 04	05	06	07	08	09	10	11	12	13
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429	.63 25	26	27	28	29	30	31	32	33	34

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431	.63 45	46	47	48	49	50	51	52	53	54
432	.63 55	56	57	58	59	60	61	62	63	64
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436	.63 95	96	97	98	99	*00	*01	*02	*03	*04
437	.64 05	06	07	08	09	10	11	12	13	14
438	.64 15	16	17	18	19	20	21	22	23	24
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441	.64 44	45	46	47	48	49	50	51	52	53
442	.64 54	55	56	57	58	59	60	61	62	63
443	.64 64	65	66	67	68	69	70	71	72	73
444	.64 74	75	76	77	78	79	80	81	82	83
445	.64 84	85	86	87	88	88	89	90	91	92
446	.64 93	94	95	96	97	98	99	*00	*01	*02
447	.65 03	04	05	06	07	08	09	10	11	12
448	.65 13	14	15	16	17	18	19	20	21	21
449	.65 22	23	24	25	26	27	28	29	30	31
450	.65 32	33	34	35	36	37	38	39	40	41
451	.65 42	43	44	45	46	47	48	49	49	50
452	.65 51	52	53	54	55	56	57	58	59	60
453	.65 61	62	63	64	65	66	67	68	69	70
454	.65 71	72	72	73	74	75	76	77	78	79
455	.65 80	81	82	83	84	85	86	87	88	89
456	.65 90	91	92	93	93	94	95	96	97	98
457	.65 99	*00	*01	*02	*03	*04	*05	*06	*07	*08
458	.66 09	10	11	11	12	13	14	15	16	17
459	.66 18	19	20	21	22	23	24	25	26	27

N.	0	1	2	3	4	5	6	7	8	9
460	.66 28	29	29	30	31	32	33	34	35	36
461	.66 37	38	39	40	41	42	43	44	45	45
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463	.66 56	57	58	59	60	60	61	62	63	64
464	.66 65	66	67	68	69	70	71	72	73	74
465	.66 75	75	76	77	78	79	80	81	82	83
466	.66 84	85	86	87	88	89	89	90	91	92
467	.66 93	94	95	96	97	98	99	*00	*01	*02
468	.67 02	03	04	05	06	07	08	09	10	11
469	.67 12	13	14	15	15	16	17	18	19	20
470	.67 21	22	23	24	25	26	27	27	28	29
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472	.67 39	40	41	42	43	44	45	46	47	48
473	.67 49	50	50	51	52	53	54	55	56	57
474	.67 58	59	60	61	61	62	63	64	65	66
475	.67 67	68	69	70	71	72	72	73	74	75
476	.67 76	77	78	79	80	81	82	82	83	84
477	.67 85	86	87	88	89	90	91	92	92	93
478	.67 94	95	96	97	98	99	*00	*01	*02	*02
479	.68 03	04	05	06	07	08	09	10	11	12
480	.68 12	13	14	15	16	17	18	19	20	21
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483	.68 39	40	41	42	43	44	45	46	47	48
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486	.68 66	67	68	69	70	71	72	73	74	74
487	.68 75	76	77	78	79	80	81	82	82	83
488	.68 84	85	86	87	88	89	90	90	91	92
489	.68 93	94	95	96	97	98	98	99	*00	*01

N.	0	1	2	3	4	5	6	7	8	9
490	.69 02	03	04	05	06	06	07	08	09	10
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496	.69 55	56	57	57	58	59	60	61	62	63
497	.69 64	64	65	66	67	68	69	70	71	71
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499	.69 81	82	83	84	84	85	86	87	88	89
500	.69 90	91	91	92	93	94	95	96	97	98
501	.69 98	99	*00	*01	*02	*03	*04	*04	*05	*06
502	.70 07	08	09	10	10	11	12	13	14	15
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505	.70 33	34	35	35	36	37	38	39	40	41
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509	.70 67	68	69	70	71	71	72	73	74	75
510	.70 76	77	77	78	79	80	81	82	83	83
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512	.70 93	94	94	95	96	97	98	99	99	*00
513	.71 01	02	03	04	05	05	06	07	08	09
514	.71 10	10	11	12	13	14	15	16	16	17
515	.71 18	19	20	21	21	22	23	24	25	26
516	.71 26	27	28	29	30	31	32	32	33	34
517	.71 35	36	37	37	38	39	40	41	42	42
518	.71 43	44	45	46	47	47	48	49	50	51
519	.71 52	53	53	54	55	56	57	58	58	59

N.	0	1	2	3	4	5	6	7	8	9
520	.71 60	61	62	63	63	64	65	66	67	68
521	.71 68	69	70	71	72	73	73	74	75	76
522	.71 77	78	78	79	80	81	82	83	83	84
523	.71 85	86	87	88	88	89	90	91	92	92
524	.71 93	94	95	96	97	97	98	99	*00	*01
525	.72 02	02	03	04	05	06	07	07	08	09
526	.72 10	11	12	12	13	14	15	16	16	17
527	.72 18	19	20	21	21	22	23	24	25	26
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533	.72 67	68	69	70	71	71	72	73	74	75
534	.72 75	76	77	78	79	79	80	81	82	83
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536	.72 92	92	93	94	95	96	97	97	98	99
537	.73 00	01	01	02	03	04	05	05	06	07
538	.73 08	09	09	10	11	12	13	13	14	15
539	.73 16	17	17	18	19	20	21	22	22	23
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541	.73 32	33	34	34	35	36	37	38	38	39
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543	.73 48	49	50	50	51	52	53	54	54	55
544	.73 56	57	58	58	59	60	61	62	62	63
545	.73 64	65	66	66	67	68	69	70	70	71
546	.73 72	73	74	74	75	76	77	77	78	79
547	.73 80	81	81	82	83	84	85	85	86	87
548	.73 88	89	89	90	91	92	93	93	94	95
549	.73 96	97	97	98	99	*00	*00	*01	*02	*03

N.	0	1	2	3	4	5	6	7	8	9
550	·74 04	04	05	06	07	08	08	09	10	11
551	·74 12	12	13	14	15	15	16	17	18	19
552	·74 19	20	21	22	23	23	24	25	26	26
553	·74 27	28	29	30	30	31	32	33	34	34
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555	·74 43	44	44	45	46	47	48	48	49	50
556	·74 51	52	52	53	54	55	55	56	57	58
557	·74 59	59	60	61	62	62	63	64	65	66
558	·74 66	67	68	69	69	70	71	72	73	73
559	·74 74	75	76	76	77	78	79	80	80	81
560	·74 82	83	83	84	85	86	87	87	88	89
561	·74 90	90	91	92	93	93	94	95	96	97
562	·74 97	98	99	*00	*00	*01	*02	*03	*04	*04
563	·75 05	06	07	07	08	09	10	10	11	12
564	·75 13	14	14	15	16	17	17	18	19	20
565	·75 20	21	22	23	24	24	25	26	27	27
566	·75 28	29	30	30	31	32	33	34	34	35
567	·75 36	37	37	38	39	40	40	41	42	43
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569	·75 51	52	53	53	54	55	56	56	57	58
570	·75 59	60	60	61	62	63	63	64	65	66
571	·75 66	67	68	69	69	70	71	72	72	73
572	·75 74	75	75	76	77	78	79	79	80	81
573	·75 82	82	83	84	85	85	86	87	88	88
574	·75 89	90	91	91	92	93	94	94	95	96
575	75 97	97	98	99	*00	*00	*01	*02	*03	*03
576	·76 04	05	06	06	07	08	09	09	10	11
577	·76 12	13	13	14	15	16	16	17	18	19
578	·76 19	20	21	22	22	23	24	25	25	26
579	·76 27	28	28	29	30	31	31	32	33	34

N.	0	1	2	3	4	5	6	7	8	9
580	·76 34	35	36	37	37	38	39	40	40	41
581	·76 42	43	43	44	45	45	46	47	48	48
582	·76 49	50	51	51	52	53	54	54	55	56
583	·76 57	57	58	59	60	60	61	62	63	63
584	·76 64	65	66	66	67	68	69	69	70	71
585	·76 72	72	73	74	75	75	76	77	77	78
586	·76 79	80	80	81	82	83	83	84	85	86
587	·76 86	87	88	89	89	90	91	92	92	93
588	·76 94	95	95	96	97	97	98	99	*00	*00
589	·77 01	02	03	03	04	05	06	06	07	08
590	·77 09	09	10	11	11	12	13	14	14	15
591	·77 16	17	17	18	19	20	20	21	22	22
592	·77 23	24	25	25	26	27	28	28	29	30
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594	·77 38	39	39	40	41	42	42	43	44	44
595	·77 45	46	47	47	48	49	50	50	51	52
596	·77 52	53	54	55	55	56	57	58	58	59
597	·77 60	60	61	62	63	63	64	65	66	66
598	·77 67	68	68	69	70	71	71	72	73	74
599	·77 74	75	76	76	77	78	79	79	80	81
600	·77 82	82	83	84	84	85	86	87	87	88
601	·77 89	89	90	91	92	92	93	94	95	95
602	·77 96	97	97	98	99	*00	*00	*01	*02	*02
603	·78 03	04	05	05	06	07	07	08	09	10
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605	·78 18	18	19	20	20	21	22	23	23	24
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613	.78 75	75	76	77	77	78	79	80	80	81
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627	.79 73	73	74	75	75	76	77	78	78	79
628	.79 80	80	81	82	82	83	84	84	85	86
629	.79 87	87	88	89	89	90	91	91	92	93
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644	.80 89	90	90	91	92	92	93	94	94	95
645	.80 96	96	97	98	98	99	*00	*00	*01	*02
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658	.81 82	83	84	84	85	86	86	87	88	88
659	.81 89	90	90	91	91	92	93	93	94	95
660	.81 95	96	97	97	98	99	99	*00	*01	*01
661	.82 02	03	03	04	05	05	06	07	07	08
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671	.82 67	68	69	69	70	70	71	72	72	73
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674	.82 87	87	88	89	89	90	90	91	92	92
675	.82 93	94	94	95	96	96	97	98	98	99
676	.82 99	*00	*01	*01	*02	*03	*03	*04	*05	*05
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691	.83 95	95	96	97	97	98	99	99	*00	*00
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701	.84 57	58	58	59	60	60	61	62	62	63
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716	.85 49	50	50	51	52	52	53	53	54	55
717	.85 55	56	56	57	58	58	59	59	60	61
718	.85 61	62	62	63	64	64	65	65	66	67
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720	.85 73	74	75	75	76	76	77	78	78	79
721	.85 79	80	81	81	82	82	83	84	84	85
722	.85 85	86	87	87	88	88	89	90	90	91
723	.85 91	92	93	93	94	94	95	96	96	97
724	.85 97	98	99	99	*00	*00	*01	*02	*02	*03
725	.86 03	04	05	05	06	06	07	08	08	09
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734	.86 57	58	58	59	59	60	61	61	62	62
735	.86 63	63	64	65	65	66	66	67	68	68
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737	.86 75	75	76	76	77	78	78	79	79	80
738	.86 81	81	82	82	83	84	84	85	85	86
739	.86 86	87	88	88	89	89	90	91	91	92
740	.86 92	93	93	94	95	95	96	96	97	98
741	.86 98	99	99	*00	*01	*01	*02	*02	*03	*03
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751	.87 56	57	58	58	59	59	60	60	61	62
752	.87 62	63	63	64	64	65	66	66	67	67
753	.87 68	69	69	70	70	71	71	72	73	73
754	.87 74	74	75	75	76	77	77	78	78	79
755	.87 79	80	81	81	82	82	83	83	84	85
756	.87 85	86	86	87	88	88	89	89	90	90
757	.87 91	92	92	93	93	94	94	95	96	96
758	.87 97	97	98	98	99	*00	*00	*01	*01	*02
759	.88 02	03	04	04	05	05	06	06	07	08

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760	.88 08	09	09	10	10	11	12	12	13	13
761	.88 14	14	15	16	16	17	17	18	18	19
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767	.88 48	49	49	50	50	51	51	52	52	53
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770	.88 65	65	66	67	67	68	68	69	69	70
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772	.88 76	77	77	78	78	79	80	80	81	81
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774	.88 87	88	89	89	90	90	91	91	92	92
775	.88 93	94	94	95	95	96	96	97	97	98
776	.88 99	99	*00	*00	*01	*01	*02	*03	*03	*04
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787	.89 60	60	61	61	62	63	63	64	64	65
788	.89 65	66	66	67	67	68	69	69	70	70
789	.89 71	71	72	72	73	74	74	75	75	76

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792	.89 87	88	88	89	89	90	91	91	92	92
793	.89 93	93	94	94	95	95	96	97	97	98
794	.89 98	99	99	*00	*00	*01	*01	*02	*03	*03
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812	.90 96	96	97	97	98	98	99	99	*00	*00
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831	.91 96	97	97	98	98	99	99	*00	*00	*01
832	.92 01	02	02	03	03	04	04	05	05	06
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847	.92 79	79	80	80	81	81	82	82	83	83
848	.92 84	84	85	85	86	87	87	88	88	89
849	.92 89	90	90	91	91	92	92	93	93	94

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850	.92 94	95	95	96	96	97	97	98	98	99
851	.92 99	*00	*00	*01	*01	*02	*02	*03	*03	*04
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868	.93 85	86	86	87	87	88	88	89	89	90
869	.93 90	91	91	92	92	93	93	94	94	95
870	.93 95	96	96	97	97	98	98	99	99	*00
871	.94 00	01	01	02	02	03	03	04	04	05
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880	.94 45	45	46	46	47	47	48	48	49	49
881	.94 50	50	51	51	52	52	53	53	54	54
882	.94 55	55	56	56	57	57	58	58	59	59
883	.94 60	60	61	61	62	62	63	63	64	64
884	.94 65	65	66	66	66	67	67	68	68	69
885	.94 69	70	70	71	71	72	72	73	73	74
886	.94 74	75	75	76	76	77	77	78	78	79
887	.94 79	80	80	81	81	82	82	83	83	84
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889	.94 89	90	90	90	91	91	92	92	93	93
890	.94 94	94	95	95	96	96	97	97	98	98
891	.94 99	99	*00	*00	*01	*01	*02	*02	*03	*03
892	.95 04	04	05	05	06	06	07	07	08	08
893	.95 09	09	09	10	10	11	11	12	12	13
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897	.95 28	28	29	29	30	30	31	31	32	32
898	.95 33	33	34	34	35	35	36	36	37	37
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